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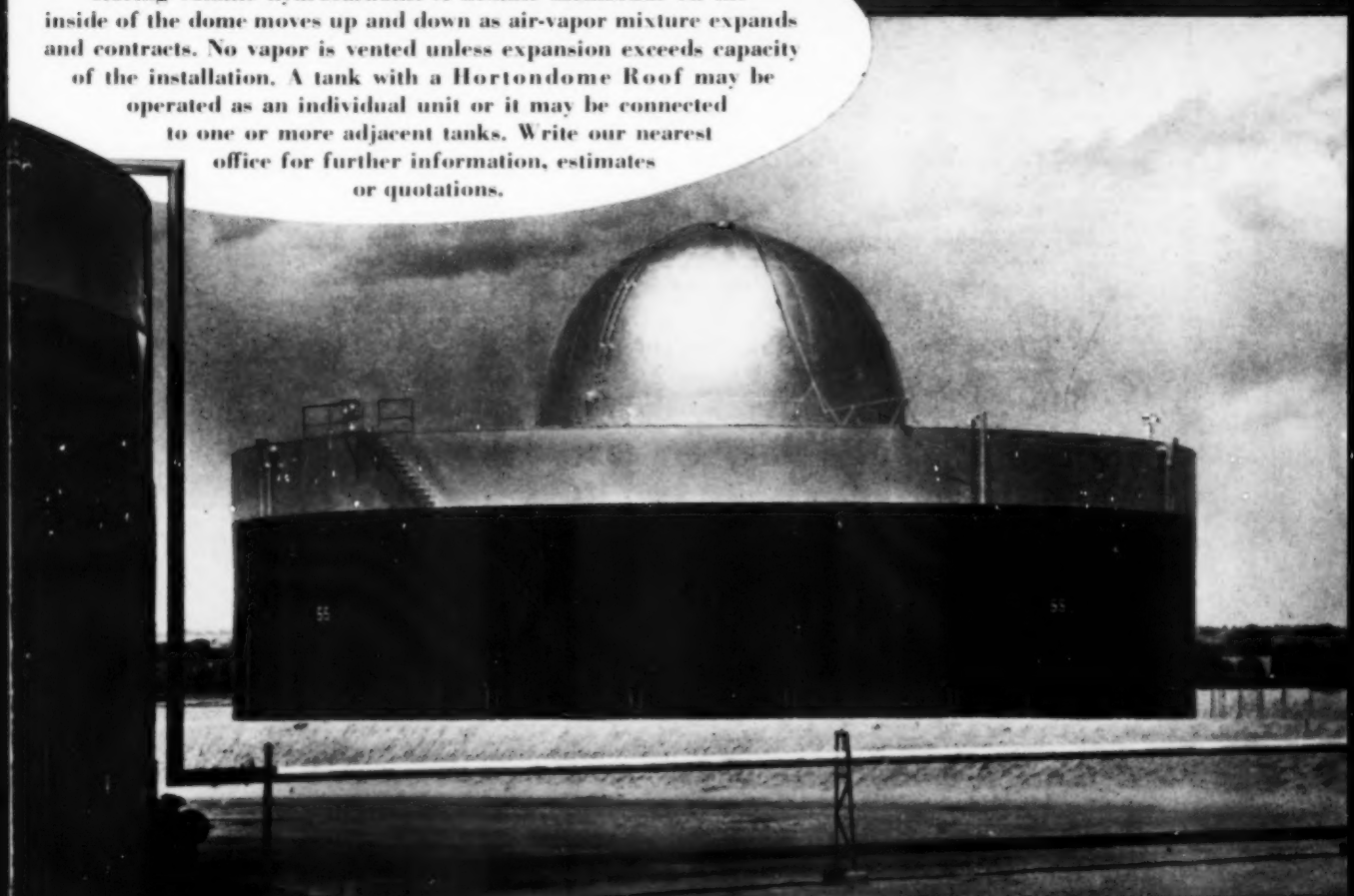
A Hortondome Roof, like the one shown below, will reduce breathing evaporation losses from tanks storing volatile hydrocarbons. A flexible membrane on the inside of the dome moves up and down as air-vapor mixture expands and contracts. No vapor is vented unless expansion exceeds capacity of the installation. A tank with a Hortondome Roof may be operated as an individual unit or it may be connected to one or more adjacent tanks. Write our nearest office for further information, estimates or quotations.



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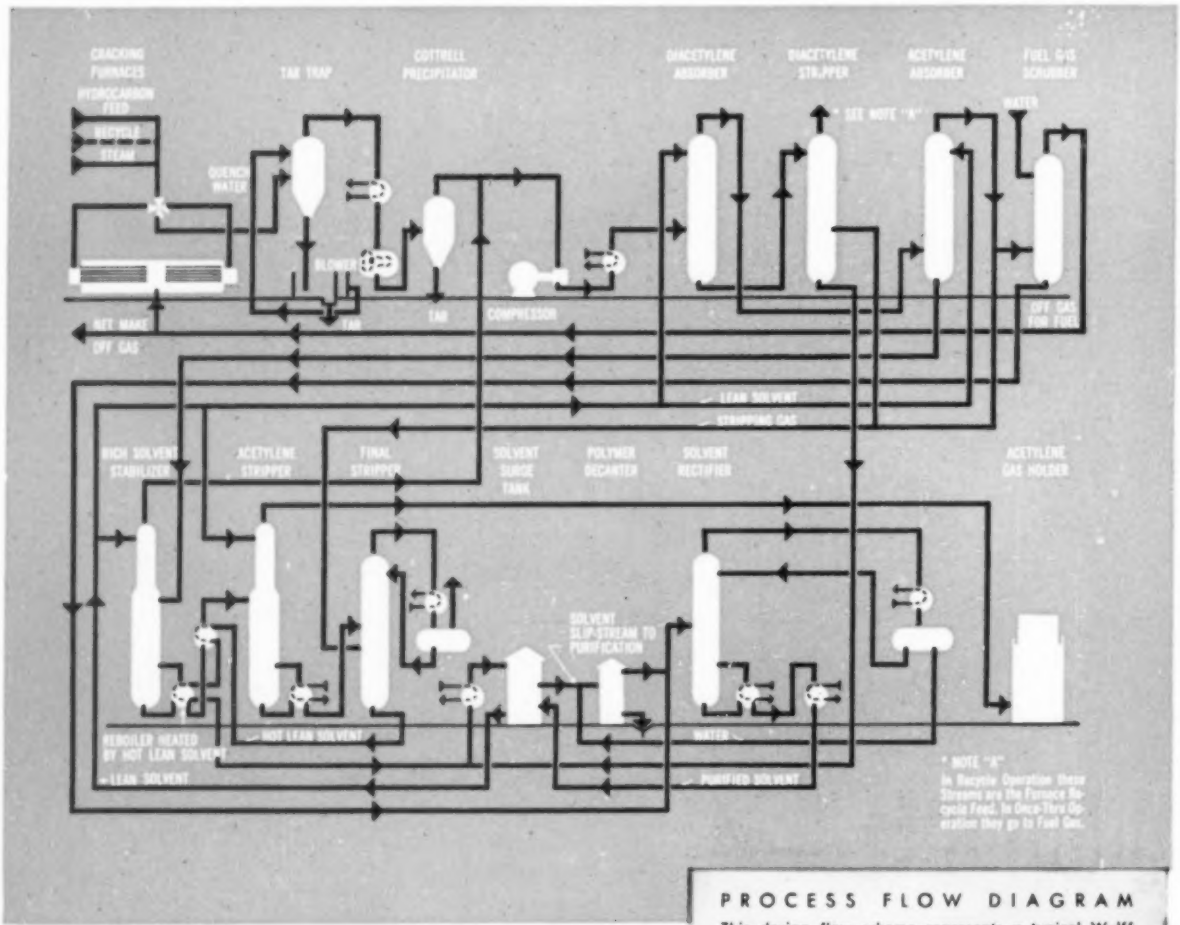
NOW—ACETYLENE FROM HYDROCARBON FEED via the Wulff Process

With heavy demands for the hundreds of petrochemical end products that may be synthesized from acetylene, the need for low-cost acetylene as a raw material is becoming urgent. The Wulff Process now answers this need with a high purity acetylene at the lowest cost ever offered by any process. Any petroleum hydrocarbon conveniently vaporizable can be used as a feed stock. Recent operations of the Wulff Process have proved it to be technically sound and commercially attractive. If your plant is convenient to a source of natural gas, ethane, propane, etc., it will pay you to investigate the possibilities of manufacturing acetylene economically by the Wulff Process.



PROCESS FLOW DIAGRAM

This design flow scheme represents a typical Wulff Process plant for producing low-cost acetylene at 99+ volume percent purity from natural gas or propane. Two basic steps are involved: cracking of hydrocarbons to produce acetylene in a mixture of gases, and recovery and purification of the dilute product contained in the cracked mixture. Feed hydrocarbon is cracked in regenerative type furnaces heated by air-combustion of off-gas from the recovery section. No oxygen plant is required. The recovery and purification section is of conventional design operating at moderate temperatures and pressures. Only a single inexpensive readily-available solvent need be used. Operation is continuous and virtually automatic, requiring a minimum of operating personnel. Power demands are moderate, maintenance costs are low, hazards are negligible and there is practically no waste disposal problem.

The Wulff Process is available through Fluor, a name famous in process design, engineering and construction for the petroleum and chemical industries. For information on recent developments in this field, write for Bulletin EC-PA-0.002.

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PETROLEUM REFINER

Specialized for Refining, Natural Gasoline and Petrochemical Engineering, Operation and Management

Volume 32, No. 7 July, 1953

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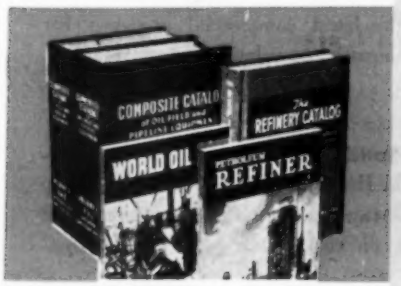


A Quick Look at

Petroleum Refiner

this month

Where Is Canada Going in Petrochemicals? . . . As a result of the natural gas discoveries in Alberta, this province is the petrochemical capital of Canada. Ammonia, ethane-ethylene products and acetylene show the strongest market potential. This article rounds out the picture with a discussion of the poor as well as favorable markets for petrochemicals. **Page 89.**

Fuel Oil Reduction Symposium . . . A 13-page extra special feature prepared exclusively for the readers of PETROLEUM REFINER. The very existence of many refiners is imperiled by the ominously low position of the fuel oil market. Alert, aggressive action is essential to escape disaster. Progressive refiners will find every page of this symposium a gold mine of ideas, stripped of non-essentials and reduced to the vital core of factual information and practical suggestions. All refiners, large or small, will regard the Foreword as *must* reading for therein is presented a practical, workable emergency solution for the immediate problem as it exists today. Following the Foreword, three very capable authors demonstrate that residual coking is an excellent solution to the long-range problem and back up their deductions with the best of all possible evidence—economics. The balance of the symposium is devoted to short, accurate descriptions of the available coking processes plus an additional feature on how to get the most out of your present equipment. Seldom has so much critically important information been packed into so few pages. For a reading experience that will pay rich dividends for you and your company, turn to **Page 97.**

Non-Hydrocarbon Constituents of Petroleum . . . Oxygen Compounds. Continuing the series of "Understanding the Chemistry of Petrochemical Reactions" the writer discusses the amount and types of oxygen compounds found in various crudes. Various aliphatic and naphthenic acids and cresylic are listed. Methods of synthesis of phenol are also given. **Page 110.**

Solve for Vessel Thickness Graphically . . . Use this short-cut method to determine shell and head thicknesses for vessels under internal pressure. It can easily be used for estimating and for quick checks. Based on the ASME code, this method can also be used to see the effect one variable has upon the others. **Page 112.**

The Selling Price for Synthetic Rubber Plants . . . An expert appraisal by three highly qualified engineers backs up this report on the selling price the government should expect for its synthetic rubber facilities, currently owned by RFC. The tricky in's and out's of depreciation are smoked out, and full consideration is given to original investment, replacement cost, effect on price of synthetic rubber, raw material cost and availability. The authors give a good accounting of the economic bases used and provide a reasonable answer to a touchy and controversial issue. **Page 113.**

Refining With Adsorbents—Part II . . . Efficiency of adsorbents must be evaluated in the laboratory by procedures correlated to actual plant performance. The second part of this important series details the analytical procedures involved and offers valuable information on the manner in which adsorbents are being used in the latest commercial processes for separating components into relatively pure fractions. **Page 119.**

Visualizing Gas-Solid Dynamics in Catalytic Processes . . . The Hydrocarbon Research, Inc., group spent more than two years in experimentation and literature research to develop "Phase Diagrams"

which are invaluable to an understanding of fluid-solids flow. The vast development of processes for catalytic cracking and hydrocarbon synthesis during the past two decades stimulated a renewed research interest in the behavior of two-phase fluid-solid systems. Every region of flow conditions of gas-solids systems has been commercially adapted in some branch of the chemical industry and cracking industry. Here you can "see" the operation simultaneously with the flow characteristic. **Page 123.**

Learning How to Use Dimensional Analysis . . . The concluding part of this series shows how to use the Buckingham Pi Theorem, replete with examples illustrating: (1) how you should analyze your problem; (2) how to take the minimum amount of data for the maximum results (3) how you should correlate these data. In addition to these three important parts of any investigation the writers show several methods of eliminating trial-and-error calculations. The most widely used dimensionless groups in engineering work are grouped conveniently in tabular form. **Page 129.**

Bearing Failures—Diagnoses and Prevention . . . Here are analyses of the five major causes of bearing failures—and remedies therefor. The author wastes no words in his concise presentation of the why's and wherefore's of this important maintenance problem. Included in the discussion are methods you can use to prevent failures from fatigue, seizure and wiping, corrosion, erosion, and wear. **Page 135.**

Entrainment Eliminators Save Money. Entrainment separators have proved that "filtering-out" liquids is not so different from filtering solids when the basic principles are recognized. Entrainment and its accompanying losses need no longer be tolerated. It can be controlled simply, effectively, and economically, to the benefit of countless processing operations. For the complete details on how, turn to **Page 138.**

The Use of Oxygen in the Petroleum Industry . . . In this final part of a series, Peter Sherwood covers the acetylene and ethylene manufacture by the partial combustion processes. Process problems and typical yields are discussed. A discussion of the role of oxygen in the partial oxidation of ammonia is included as well as some miscellaneous uses for oxygen in the petrochemical industry. **Page 141.**

Estimating the Corrosivity of Crude Oils . . . There has been a distressing lack of interest focused on the critical problem of predicting the corrosivity of new crudes. Equipment worth millions might be saved if the refiner could adequately prepare for the particularly bad actors. Recognizing this need, the API established a sub-committee to find the answers. For complete details, turn to **Page 145.**

Volatility Sets Automobile Performance . . . Revaluation of gasoline volatility requirements has been made necessary by recent new designs in automatic transmissions and chokes. Exhaustive tests have been conducted with six popular 1949 passenger cars to determine the effects of gasoline volatility on engine starting time, warmup, and vapor lock. For the unusual results and valuable correlations obtained from the tests, turn to **Page 151.**

Absorption Index . . . This new test for natural gas offers a simple and rapid method for estimating the amount of butane and heavier content with a precision of ± 5 percent based on fractional analysis. The test is a welcome replacement for analytical methods which are costly, time-consuming, and subject to the limitation of doing the work in a well-equipped central laboratory. **Page 155.**

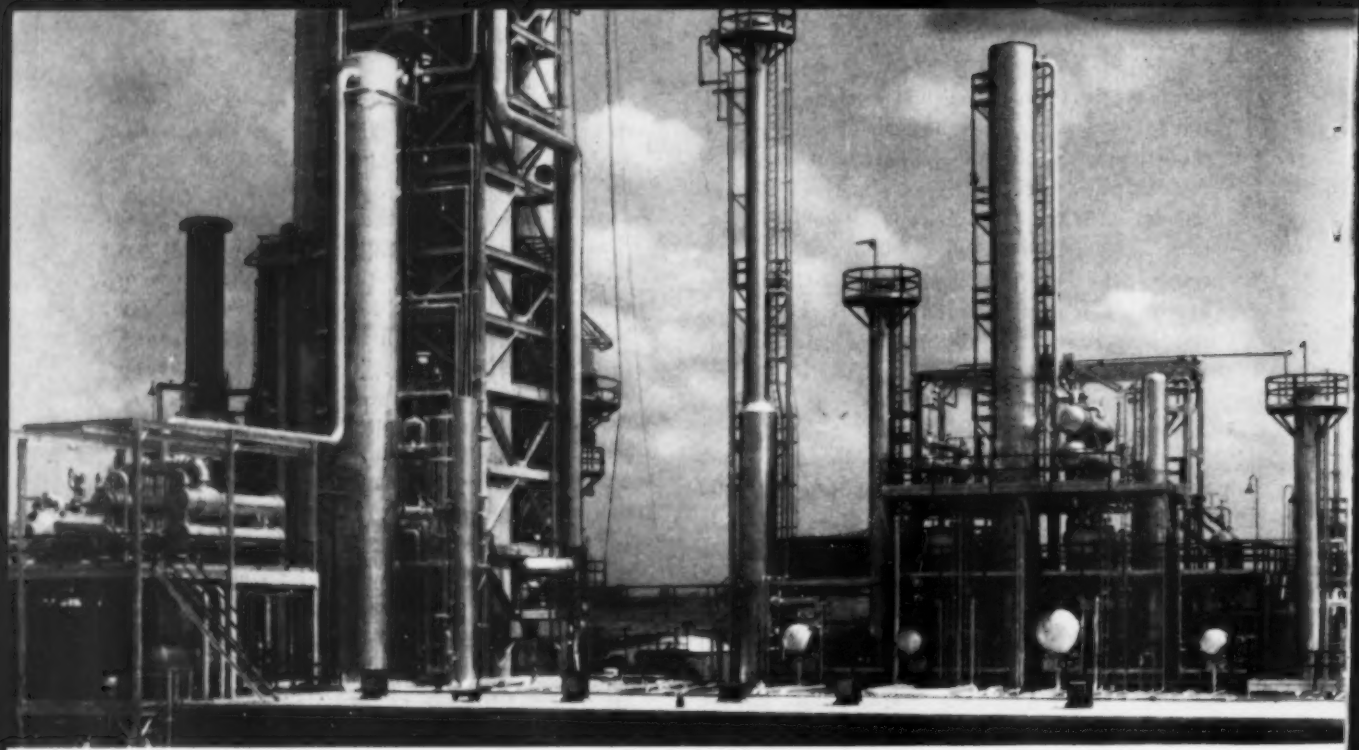
When the Big Winds Blow . . . Hurricanes are costly when they enter the critical radius of a plant. At this point the shutdown procedure must begin. Some plants require 24 hours for a shutdown, others somewhat less. For a description of how oil installations around the world guard against tropical storms, see the concluding installment of this article. **Page 211.**

Keep Those Records but Save That Money . . . Expanding businesses mean increasing paperwork and this creates many problems, such as storage, duplicating records, etc. Today's dual-lens, many-purpose cameras have a place in speeding handling of such paperwork, preserving documents and cutting storage space. See **Page 219.**

COMING

In the Near Future . . . . . .

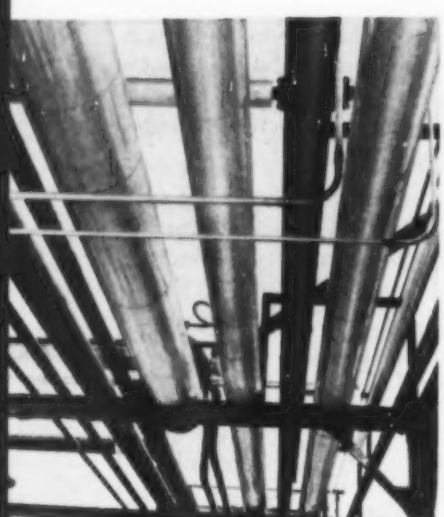
PROCESS ISSUE	**September**
PETROCHEMICALS ISSUE	**November**
MAINTENANCE ISSUE	**January**



"It cut jacketing application costs, and we expect it to last for years," report engineers at refineries everywhere after testing Childers Aluminum Jacketing on their insulated lines. This new Oklahoma refinery used Childers 100% — on towers and vessels (in heavy weight) as well as on lines. It is flexible and easy to put on, and this 35 alloy aluminum is tough and weather-resistant, even in corrosive industrial atmospheres. This is the first and only jacketing especially engineered for process plants and power installations.

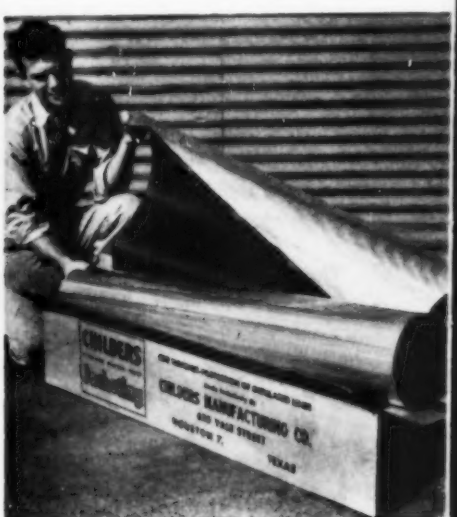
Refineries cut maintenance on insulated lines by switch to new low-cost aluminum jacketing

At least 567 processing plants have installed and tested this new Childers Aluminum Weatherproof Jacketing during the last three years. You can examine its advantages for your plant by writing for a free sample. Address Childers Manufacturing Co., Dept. PR-14, 3620 West 11th Street, Houston 8, Texas.



These lines are insured for years against wear and weather. They'll never need painting because Childers Jacketing gives them all the advantages of appearance and long life that come only with weather-resistant aluminum. Yet this specially engineered jacketing costs far less than would heavy aluminum sheets.

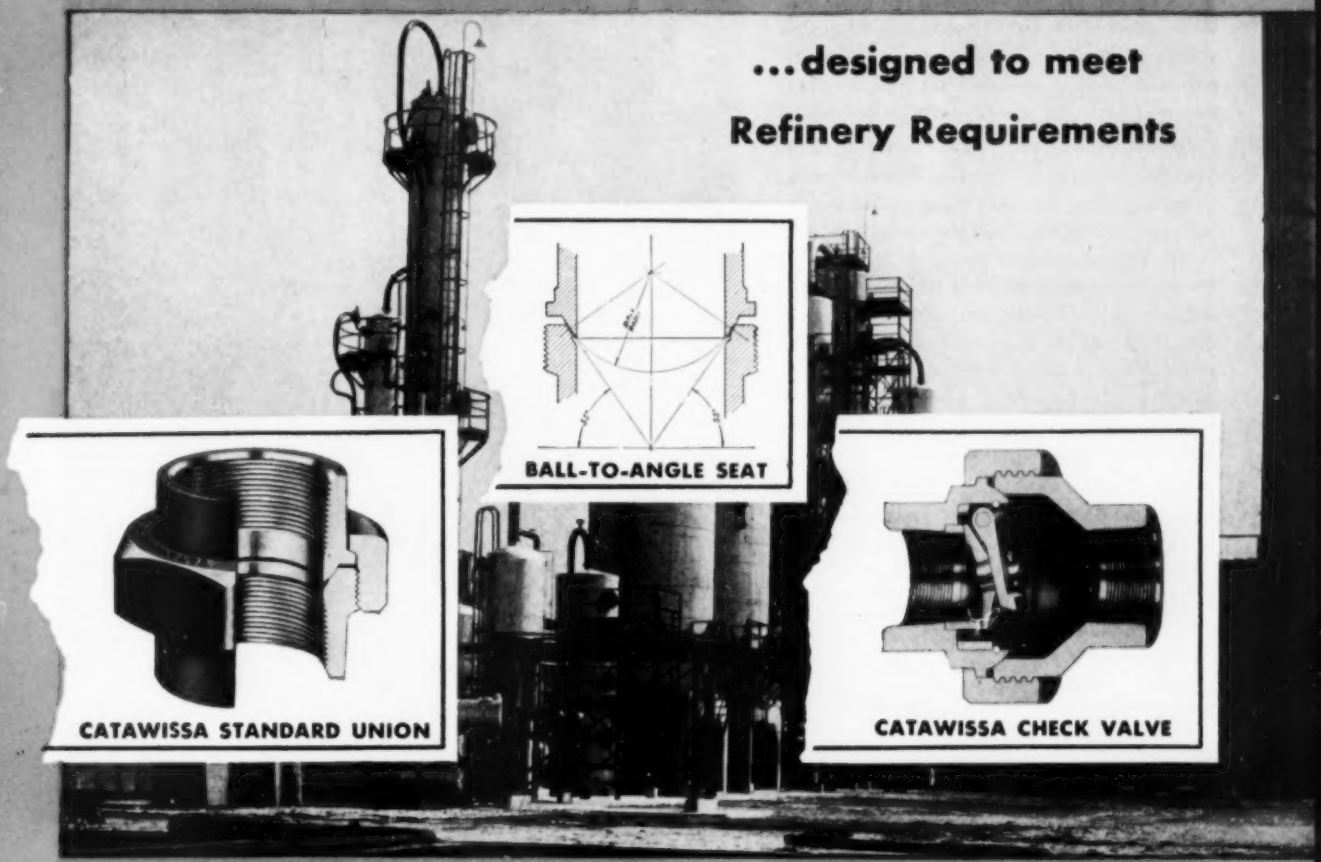
As shown here, Childers Jacketing can be attached with no more tools than a pliers and a wooden wedge. No expensive shop work or pre-forming are necessary. Several methods of attaching are available, but aluminum bands shown here are probably best and cheapest. Because this jacketing is so easy to handle and so simple to attach, it cuts installation costs way down.



This is how the flexible, easy-to-handle Childers Jacketing arrives at the job site. It is in convenient rolls 4 feet wide and 100 feet long—just right for one man to handle—and is available either with or without a moisture barrier attached on the back of the .006" aluminum "skin". It can be cut to proper lengths using any flat table and a straight-edge.

Advertisement

Always specify "CATAWISSA" Unions and Check Valves



"OILWELL'S" strategically located refinery stock points carry complete lines of Catawissa forged-steel unions and check valves that meet the most severe refinery specifications.

CHECK THESE FEATURES

HOT-FORGED . . . from solid, rectangular steel bars, Catawissa Unions are free from sand and blow holes. They will expand and contract with the pipe, assuring tight joints.

THREADS – Catawissa Unions and Valves are supplied with either full ACME threads or U. S. Standard V-threads in the union nuts and on the female end.

SEATS . . . in all Catawissa Unions are a 55° angle on the female end to a BALL on the male end, assuring a perfect seal even when the pipe is not perfectly aligned. Carefully hand-ground seats which require no packing are inspected and tested under water to assure holding qualities.

Contact your nearest "Oilwell" representative—to assist you with your refinery problems.

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USS "OILWELL"

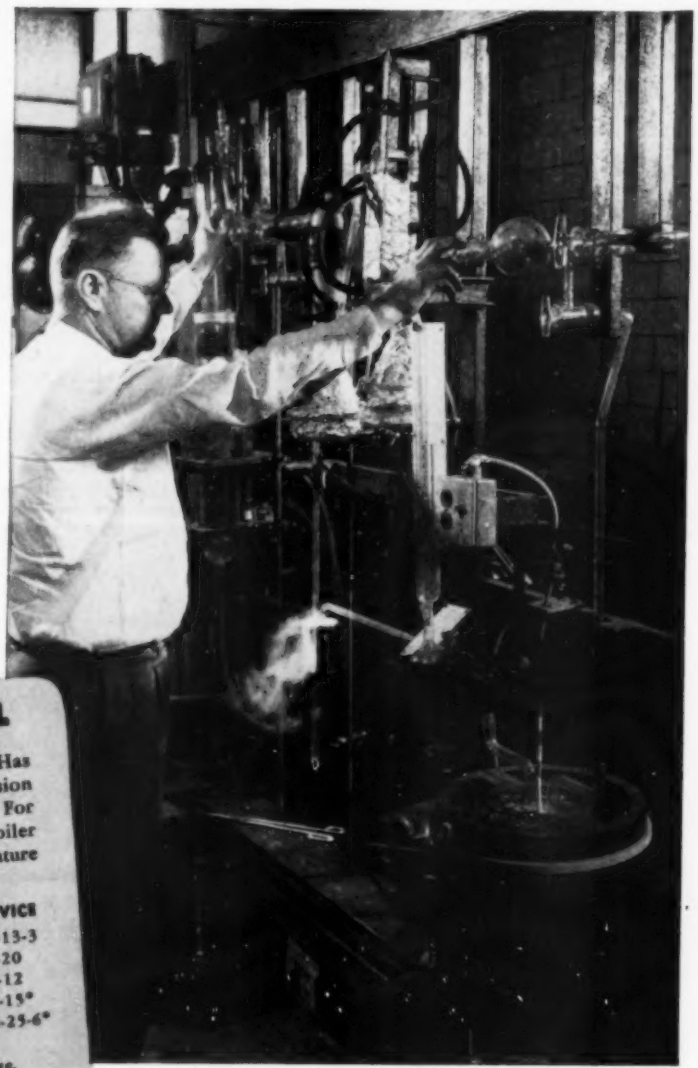
UNITED STATES STEEL

Want the one tube steel for your job that gives the best life/cost ratio? *Ask the experts!*

IT'S very likely that several of the high temperature steels listed below are adaptable to your particular conditions of heat, pressure, oxidation and corrosion. But one and only one will give you the best life to cost ratio.

To find that one steel, *ask the experts!* Ask the metallurgists of The Timken Roller Bearing Company. They're recognized authorities on high temperature steels. They're backed by 20 years' experience and research in the high temperature steel field. They'll help you choose the one best steel for your application from one of the 23 different analyses at their disposal. And you'll be assured of uniform quality in every tube because the Timken Company rigidly controls the quality of the steel from melt shop through final inspection.

The Timken Company's RSQ—Research, Supply, Quality—can solve your tube problems. *Ask the experts!* The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".



This month the Timken Company reports on:

DM-2 STEEL

Suggested as a substitute for 0.50% Mo. steel. Has greater creep strength and somewhat better corrosion and oxidation resistance than 0.50% Mo. steel. For use in cracking furnace tubes, high pressure boiler tubing, superheater tubing and high temperature steam piping.

23 TIMKEN® STEELS FOR HIGH TEMPERATURE SERVICE

Carbon	Sicromo 2	Sicromo 5S	16-13-3
Carbon-Mo.	Sicromo 2½	Sicromo 5MS	25-20
DM-2	2¼% Cr.-1% Mo.	Sicromo 7	25-12
Silmo	Sicromo 5	Sicromo 9M	35-15*
DM	4-6% Cr.-Mo.	18-8 Stainless	16-25-6*
2% Cr.-Mo.	4-6% Cr.-Mo.-Ti.	18-8 Cb	

*Not available as seamless tubing at the present time.

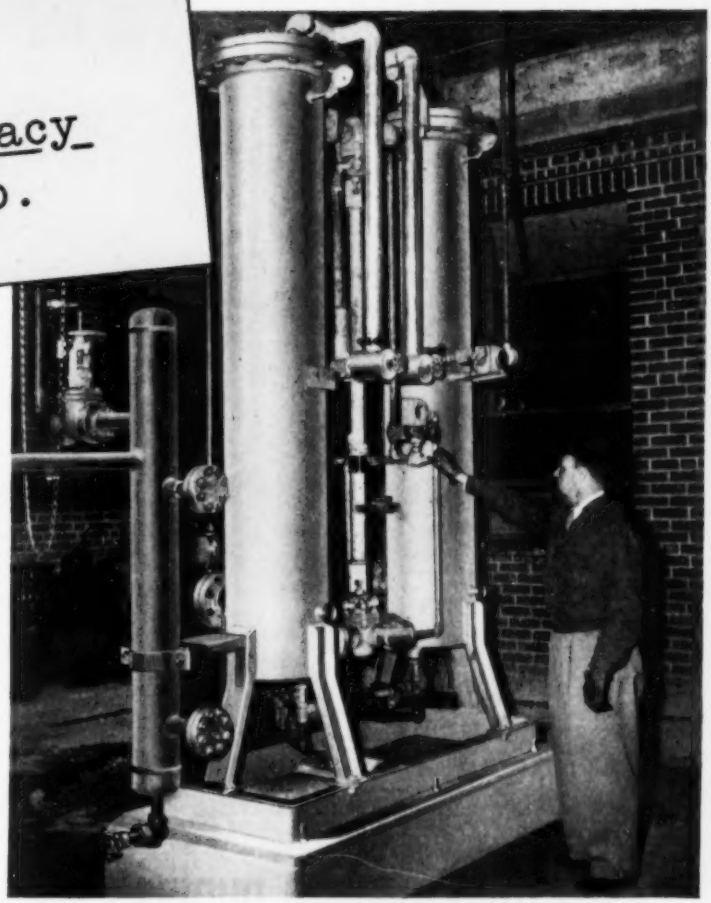
Photo above shows a vacuum fusion apparatus used to determine gases in steel. It's just one of the many phases of research on high temperature steel carried on by the Timken Company.

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

Case No. 64

Kemp Dryer Assures Accuracy For Sun Oil Co.



How SUNOCO guarantees dependable instrument readings 24 hours a day

WHEN the Sunoco Plant at Marcus Hook, Pa., introduced a new process at the beginning of the year, many new instruments were installed. To dry the compressed air operating these instruments and assure accurate readings, Sunoco installed a Kemp Model 300 S Dryer.

Kemp Dryer Entirely Satisfactory

According to Harold Powers, Instrument Supervisor at Sunoco, the Kemp Dryer has been entirely satisfactory in performance. Operating continuously day and night since installation, it has performed according to specifications, has never been saturated, and has required very little attention.

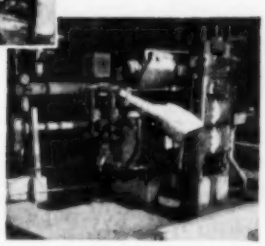
Kemp Dryers for Every Purpose

Kemp offers a variety of dryer models to meet all problems. Designed to dry air to sub-zero dew points at low cost, they are constructed of quality materials and embody the engineering knowledge gained from Kemp's many years of experience. They are available with manual, semi-automatic, or fully automatic tower reactivation. In addition, Kemp will prescribe the proper desiccant for each specific drying job. If you have a problem involving the removal of water from air, gases, or liquids, contact Kemp engineers now.

KEMP INERT GAS GENERATORS, too, serve Sunoco well

Sunoco reports that its two Kemp Inert Gas Generators have given highly satisfactory service. They are easy to start, and then operate automatically, requiring little attention. Both deliver high volume of gas of the proper analysis regardless of demand.

Kemp Inert Gas Generator Model C-5 MIHE. Delivers N_2 and CO_2 used to blanket top of wax tank.



Kemp Inert Gas Generator Model 8 MIHE. Produces N_2 and CO_2 for blanketing and for bubbler systems. Located in the open.

For more complete facts and technical information, write for Bulletin D-27 to:
THE C. M. KEMP MFG. CO., 405 East Oliver Street, Baltimore 2, Md.

KEMP OF BALTIMORE

DYNAMIC DRYERS

CARBURETORS • BURNERS • FIRE CHECKS
METAL MELTING UNITS • INERT GAS GENERATORS
SINGEING EQUIPMENT

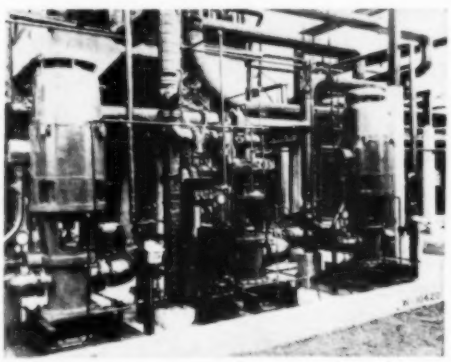
TEXAS REFINERY, where Worthington can pumps were installed because of low available suction head. The can pump's integral sump provides the necessary head for each particular pumping operation.

Worthington can pumps solve low suction head problems

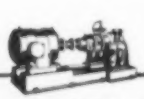
Like many other leading refineries, these two plants operate better because they use Worthington Type QR centrifugal can pumps.

Worthington Type QR pumps are specifically built to perform pumping operations where the available NPSH is limited. They have the added attraction of occupying a minimum of floor space.

Call your nearest Worthington representative for full information on our complete line of can pumps (and other centrifugal pumps), specifically designed for petroleum service. Or write to Worthington Corporation, Centrifugal Pump Division, Harrison, New Jersey, for Bulletin W341-B15. C.2.11



WORTHINGTON CAN PUMPS installed in restricted space at a large Mexican refinery.



Types HR and HB. Twenty sizes. Capacities up to 1,800 gpm. Developed heads up to 900 ft. Proper selection of material permits use for temperatures far below zero to 800 F, for pressures from high vacuum to 750 psig.

Type HD. Hydraulically-balanced double-suction impeller handles boiling liquids with low submergence. Capacities range from 600 to 3,200 gpm at heads up to 700 ft. To 850 F and 550 psig.

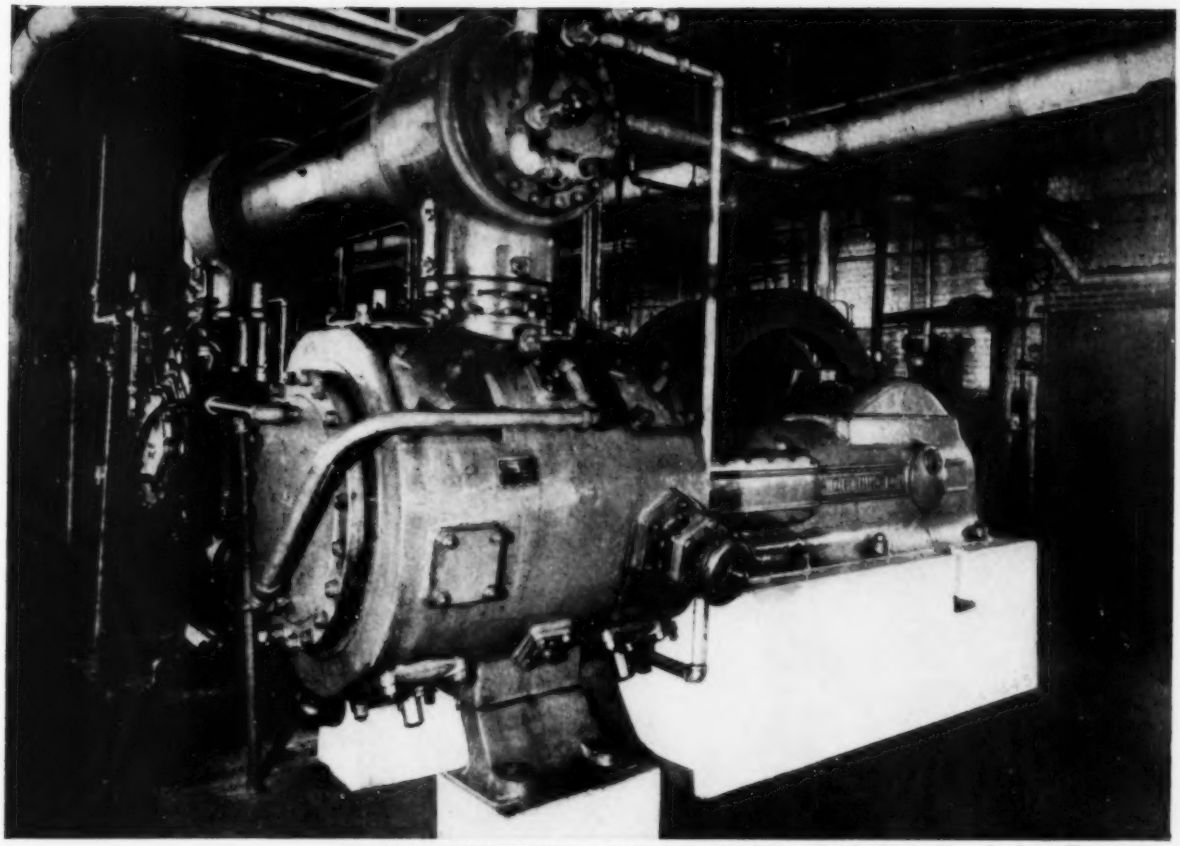
Type CNE. For loading or transfer service. Capacities to 1,500 gpm. Heads to 500 ft.

Type HM. Available in 12 sizes. Capacities to 700 gpm. Heads to 475 ft. Up to 500 F.

WORTHINGTON

Centrifugal Pumps

The World's Broadest Line Assures You the Right Pump for Every Job



ONE OF FOUR WORTHINGTON GAS COMPRESSORS in the gas distribution system of a large Eastern gas company. Compressor is positive displacement reciprocating type with capacity of 125,000 standard cu ft of manufactured gas per hour. Maximum discharge pressure is 100 psi. Volume is controlled by Worthington's automatic variable capacity control.

When a large Eastern gas company needed another gas compressor...

... There was no question about which make should be selected!

The gas compressor in the picture had been working so well since 1949 that Worthington was the logical choice for the *next* new compressor to handle expanded capacity.

These Worthington features constantly increase the number of such choices:

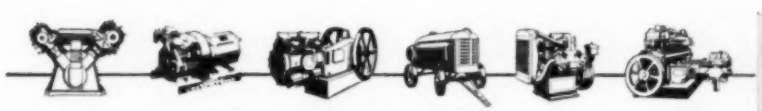
Accurate control of volume that is always assured with Worthington's automatic variable capacity control — acknowledged most accurate, flexible and simple control obtainable.

Worthington's exclusive Feather Valve* — simplest, lightest, most efficient ever made—eliminates valve problems. And Worthington's high-efficiency intercooler needs less water, less power, less attention.

Somewhere in the broad line of Worthington compressors, for air, gas or other "compressables", there is the one right type and size for your job. *Worthington Corporation, Compressor Division, Buffalo, N. Y.*

*Reg. U. S. Pat. Off.

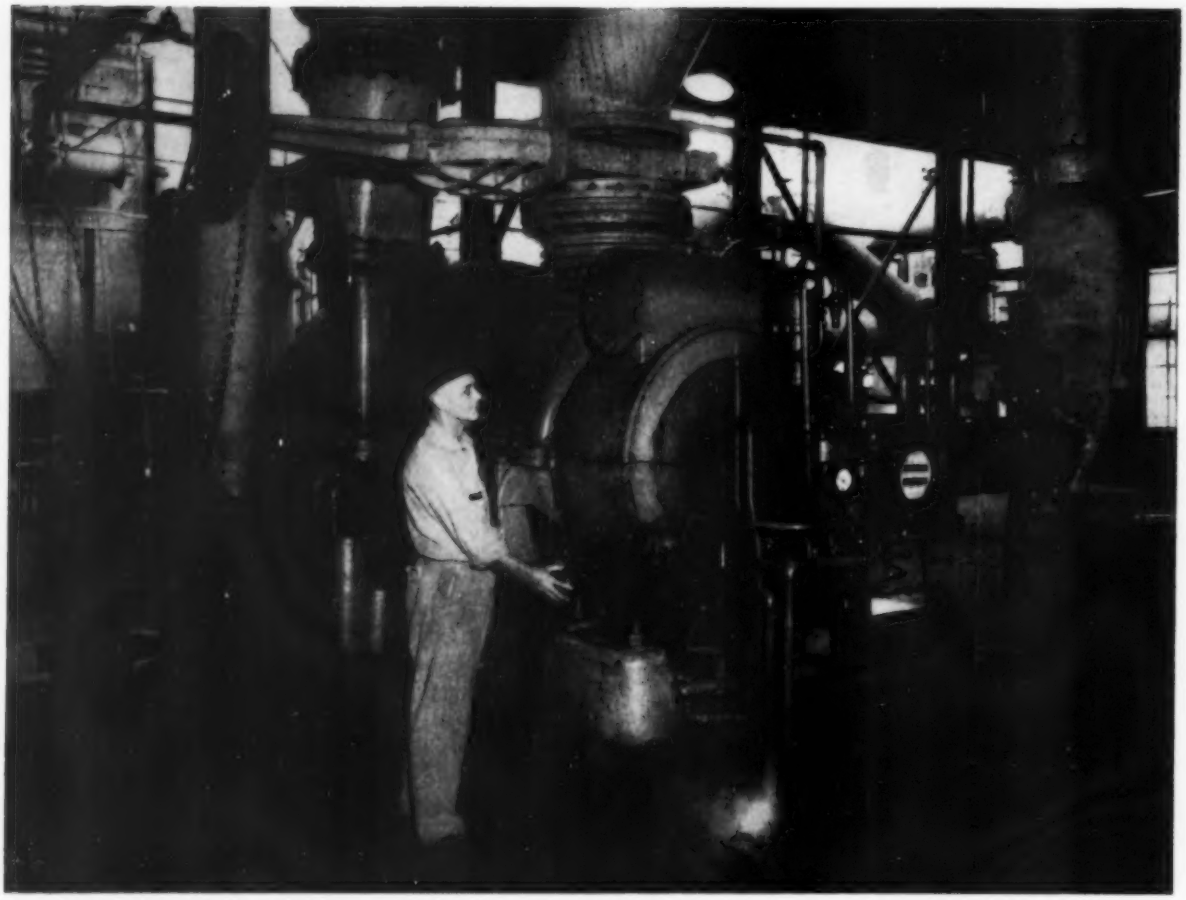
K.2.15



WORTHINGTON

Compressors

No Other Compressor Will Outperform a Worthington



WORTHINGTON 550-HP TURBINE, used to drive coke oven gas collection blower, is one of two units purchased by the Citizens Gas & Coke Company of Indianapolis. The first unit, installed in 1938, operated continuously until 1945, when the second unit was installed. Now the units alternate, providing continuous service.

Operating record of this Worthington blower-drive turbine brought repeat order

Fifteen years of dependable service and still going strong. That's the record of this 550-hp Worthington turbine, used for driving a coke oven gas collection blower.

The unit was purchased by the Citizens Gas & Coke Company of Indianapolis, Ind., early in 1938. Impressed by its performance, Citizens Gas & Coke installed another Worthington turbine in 1945 to drive a similar blower.

The long satisfactory experience that Citizens Gas & Coke has had with these turbines is duplicated by Worthington users everywhere.

Worthington turbines are ideally suited for blower or centrifugal compressor drives, since they are available in all sizes and speeds to give the most economical unit performance. Another advantage is the turbine's adaptability to various governing arrangements for precise control under all operating conditions.

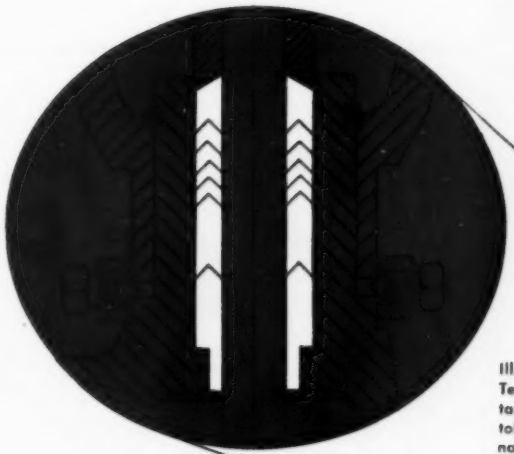
Remember, the engineering of the drive is just as important as the engineering of the compressor or blower. Worthington's long experience in compressor-drive engineering is your assurance of getting exactly the *right* type and size drive for your needs. Write for Bulletin 1966 to Worthington Corporation, Steam Turbine Division, Wellsville, N. Y. T.3.3

A GREAT TEAM IN STEAM

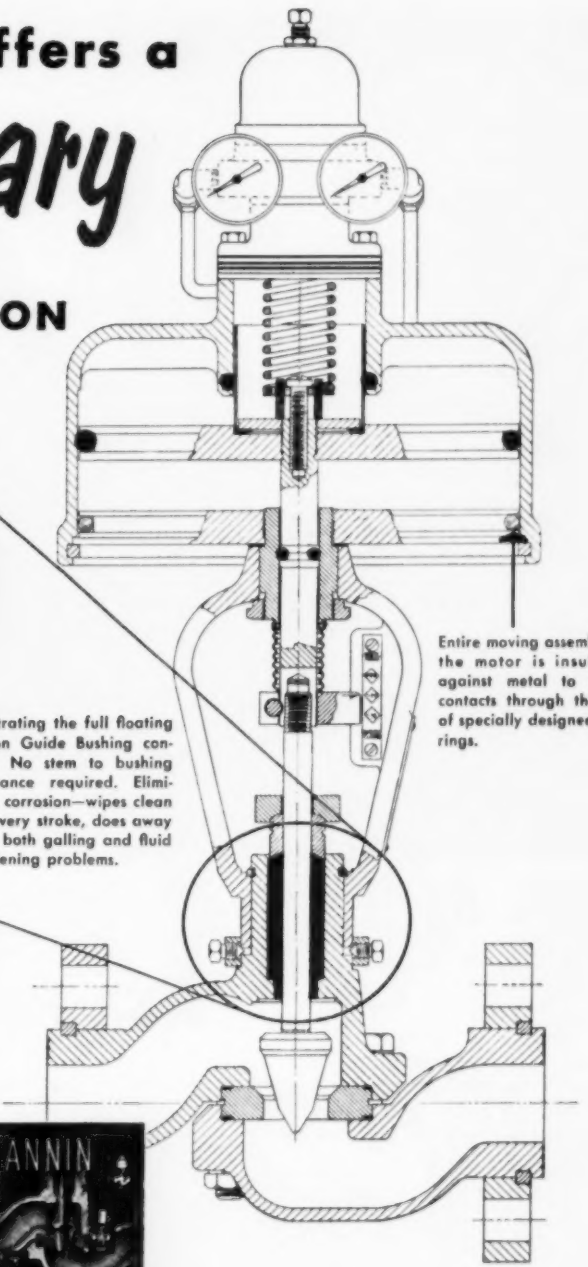
WORTHINGTON

Steam Turbines

Now ANNIN offers a *Revolutionary* PRINCIPLE IN VALVE CONSTRUCTION



Illustrating the full floating Teflon Guide Bushing contact. No stem to bushing tolerance required. Eliminate corrosion—wipes clean on every stroke, does away with both galling and fluid hardening problems.



Entire moving assembly of the motor is insulated against metal to metal contacts through the use of specially designed "O" rings.

By incorporating a Teflon Guide Bushing,—Annin design provides mechanical perfection in control valve operation. How? Because now Annin valve offers full floating operation free from any metal to metal contact in moving parts. The valve stem floats in contact with Teflon,—the Domotor portion of the valve floats on Hycar "O" rings. Teflon eliminates valve stem galling, and all difficulties which develop when soft, corrosion resisting alloys are in contact as bearings.

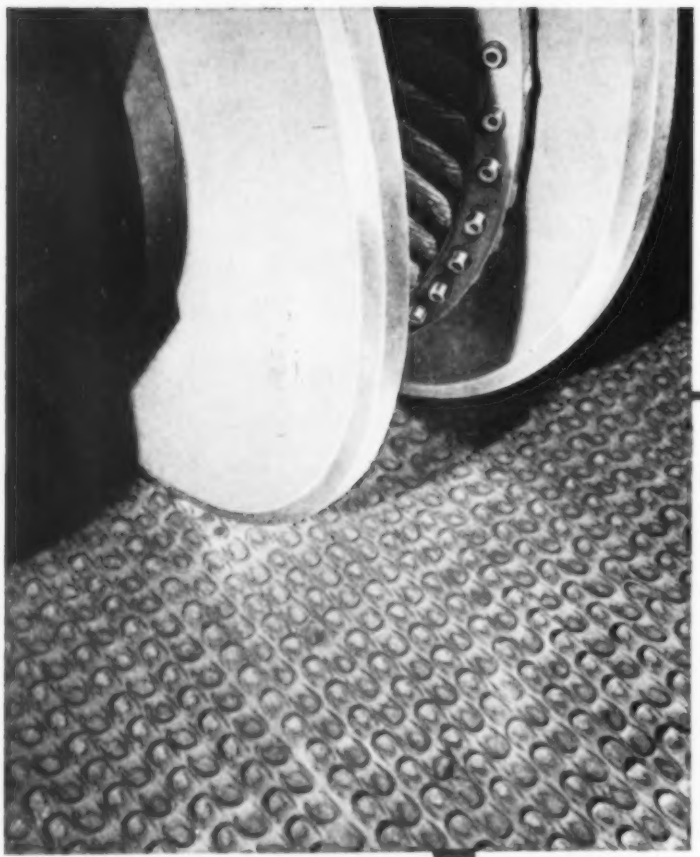
Teflon is self-lubricating and requires no external lubrication. It won't stick so the customary tolerance between guide bushing and valve stem is eliminated. With the new type guide bushing used by Annin, an interference fit is provided and solidly retains the valve stem and plug assembly. The stem is wiped clean on every stroke preventing scale or dirt from scoring or any tendency toward fluid hardening problems. Valves now in service may be changed over to the new guide material.

Write for your copy now

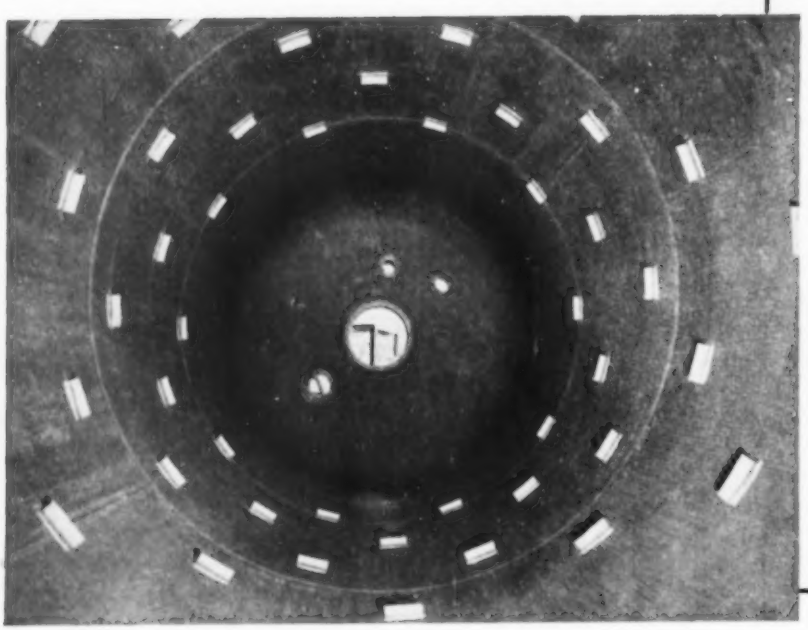
CUT INVENTORY 50% WITH

ANNIN *Control* VALVES

THE ANNIN COMPANY 3500 Union Pacific Avenue
Los Angeles 23, California



Plus Values of B&W CROLOY-

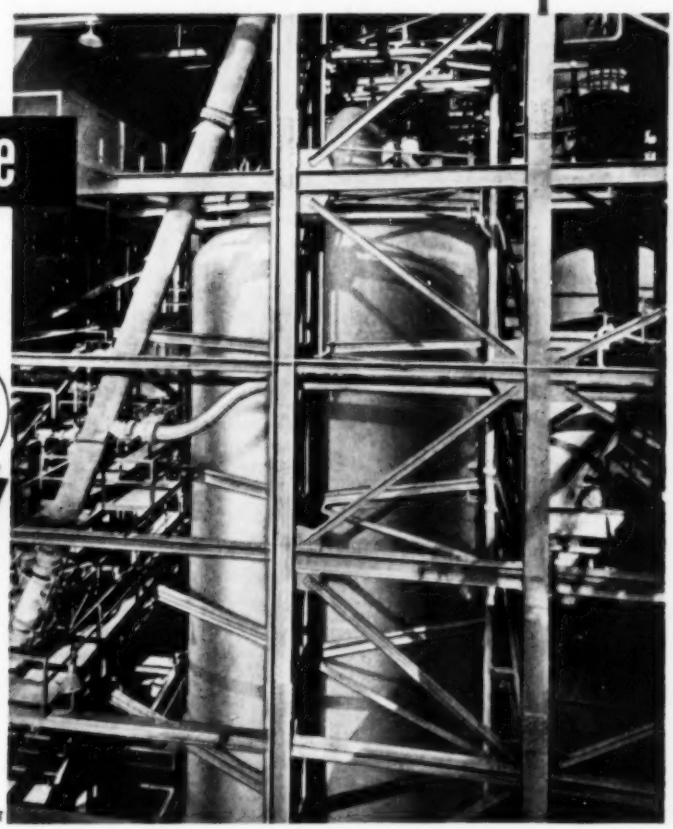


So effective is the bond between base metal and alloy liner in B&W Croloy-Clad pressure vessels that inside welded assemblies are attached directly to the stainless "skin." This faster, more economical and efficient type of assembly leaves the corrosion-resistant lining intact . . . eliminates cut-outs and welding to base metal . . . avoids the accelerated local corrosion that may result from alternative practices.

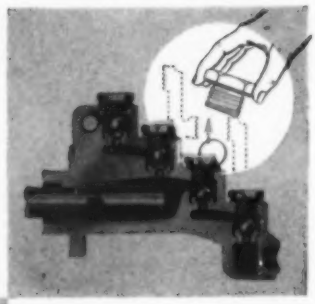
B&W Croloy cladding and base plate are permanently bonded with resistance welds • Bond withstands repeated heating and cooling • High strength of bond permits direct welding of internal fittings to Croloy lining • Uniform clad protection over full plate • Full corrosion resistance retained by heat treatment • No interface carbon migration between base metal and Croloy lining • Fabricates as easily as plain steels, and without special precautions • Provides all advantages of solid alloy protection at a great saving in cost

These features briefly explain why pressure vessels and other processing equipment built of B&W Croloy—Bonded Plate are paying dividends in dependable, lasting contact-side protection against corrosive and oxidizing conditions. Ask for Bulletin S-14. The Babcock & Wilcox Company, Process Equipment Department, Barberton, Ohio.

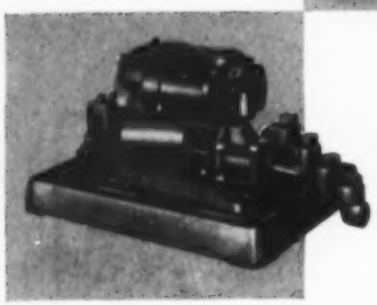
CLAD PLATE
pay dividends here



S-418T



Basic design simplicity of the *exclusive* Milton Roy liquid end step-valve assures high and reproducible volumetric efficiency. Inspection, servicing, or thorough cleaning of individual ball-checks and seats are effected without disturbing piping or other ball-checks and seats.



Two-to-One Service Life with this Milton Roy Pump

CONTROLLED VOLUME PUMPING

INSTRUMENTATION

PROCESS CONTROL SYSTEMS

BLENDING AND FORMULATING

ON THE JOB for a leading chemical manufacturer, this Milton Roy Motor-Driven Controlled Volume Pump is still going strong after 4½ years of operation . . . has needed very little maintenance. A previously employed chemical feed pump, on the other hand, lasted only 2½ years, and required considerable maintenance.

Long service life is just one of many reasons why rugged Milton Roy Pumps are in wide use throughout industry. Wherever requirements call for precise metering of measured quantities of liquid in controlled volume, there's one of these versatile instruments to do the job. Capacity of each pump is variable from 0 to 100% by any one of several mechanical or automatic means of plunger stroke or speed adjustment.

Driven by motor, or powered by air, Milton Roy Pumps meter practically any liquid . . . in capacities from 3 milliliters per *hour* to 45 gallons per *minute*, against pressures up to 25,000 pounds per square inch. They are available as single or multiple units or as component parts of complete chemical feed and control systems. We invite your inquiries.

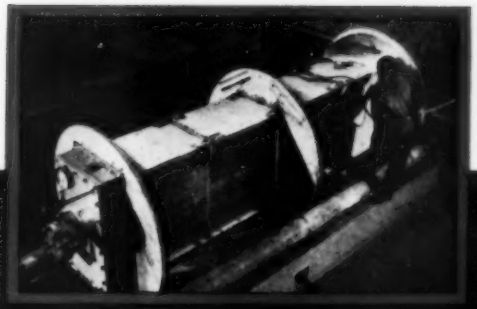
***New Bulletin No. 553** tells the complete story on Milton Roy Motor-Driven Controlled Volume Pumps and their application. Write for your **free** copy.*

Engineering Representatives in the United States, Canada, Mexico, Europe, Asia, South America and Africa.

MILTON Roy COMPANY

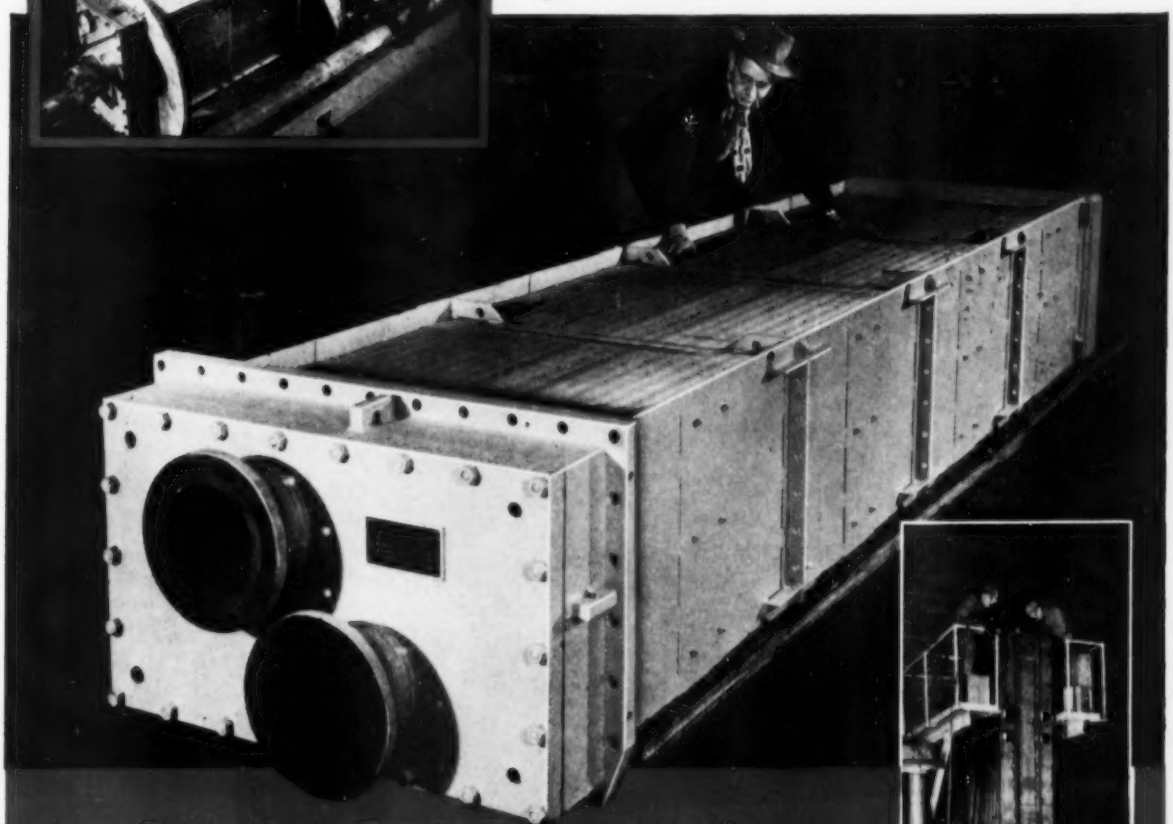
Manufacturing Engineers 1315 E. MERMAID LANE • PHILA. 18, PA.

CONTROLLED VOLUME PUMPS AND AUTOMATIC CHEMICAL FEED SYSTEMS

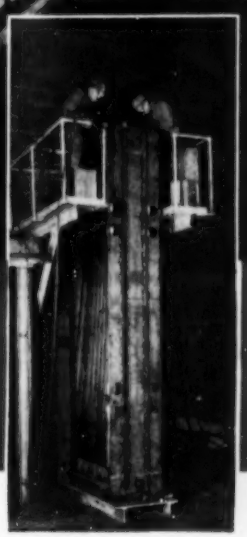


Each heat exchanger is individually hydrostatically tested to insure against leakage during operation. While under test, the by-pass baffles are welded on the unit.

One of the many wind tunnel heat exchanger sections, ready for shipment and installation in the Langley Aeronautical Laboratory supersonic wind tunnel, Langley Field, Virginia.



New **Supersonic** Wind Tunnel Coolers are A. O. Smith **Engineering Achievement**



Assembling tubes into the tube headers for one of the heat exchanger sections.

All wind tunnel coolers for the new supersonic wind tunnel under construction at Langley Aeronautical Laboratory of NACA, Langley Field, Virginia, were supplied by us.

A. O. Smith engineers conceived an original design in these heat exchangers, incorporating many advantages. The most important ones are:

1. High efficiency through balanced distribution of surface and flow areas.
2. Removable tube bundles.
3. Safety from air contamination by water, through elimination of bolted joints inside the tunnel and placing all water lines and connections outside air chamber.

These and many similar features make this one of the most advanced engineering feats in cooling provision for wind tunnels.

Besides manufacturing varying sizes and arrangements of heat exchangers, we also designed cooler housings, accessory equipment, and air by-pass system, calculated ducts and provided installation.

This is an excellent *example* of the completeness and flexibility of A. O. Smith engineering which is available to you to help solve YOUR heat exchanger problems . . . available through our nearest office, listed below.

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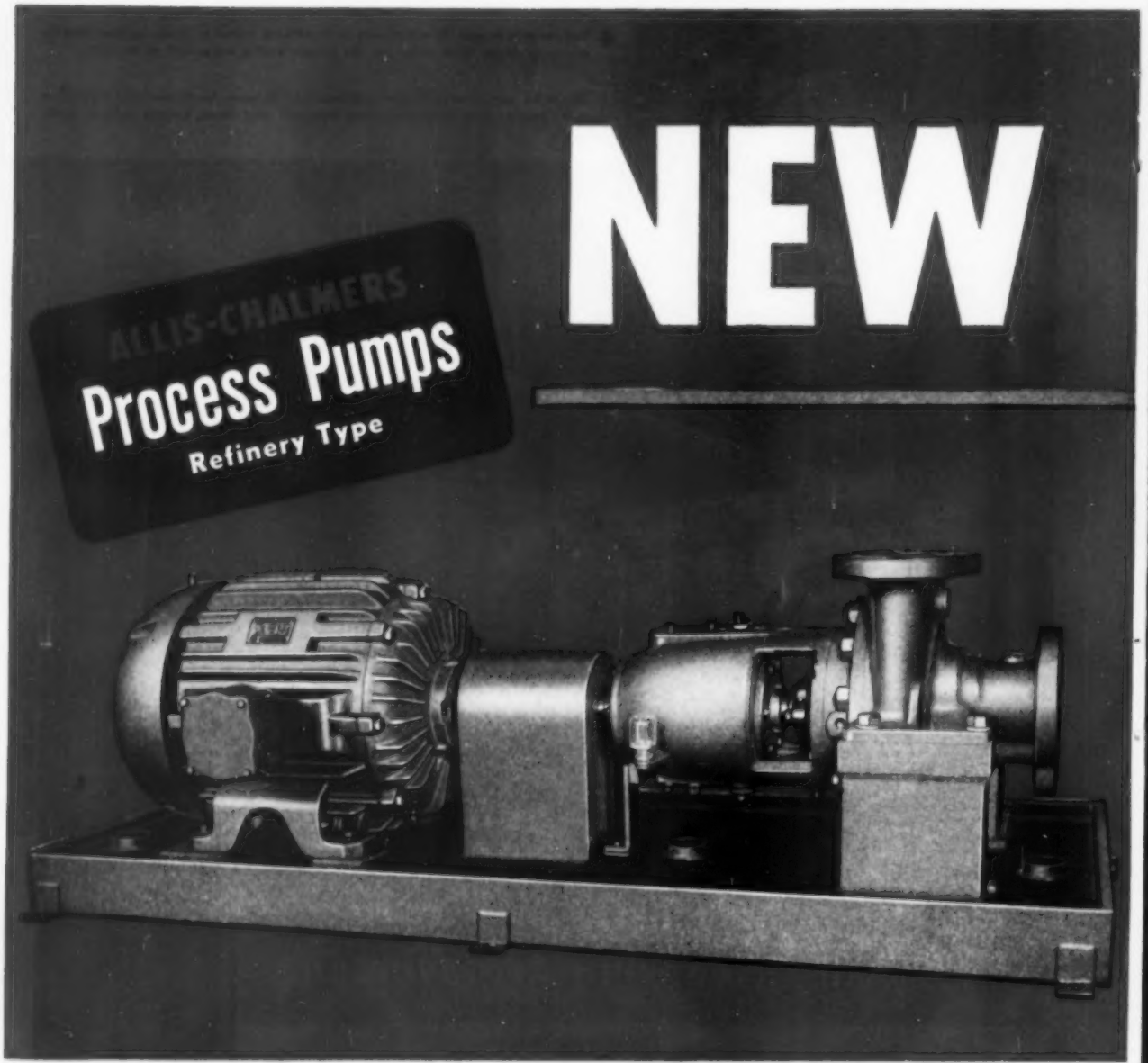
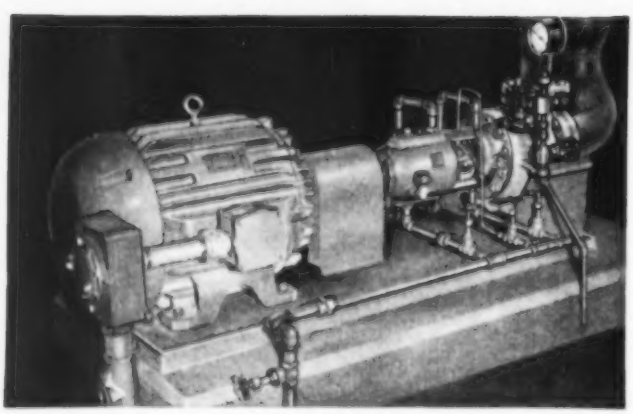


Easy Installation and Maintenance



All Allis-Chalmers Type R pumps are furnished with spacer-type couplings. This type of coupling permits the pump to be disconnected from the driver and the entire rotating element — bearing bracket, shaft and impeller — removed without disturbing either the piping or the driver. This type of assembly permits quick examination of the pump, simplifies repairs or replacements and keeps downtime of the unit to a minimum.

In addition, two sets of bearing bracket assemblies fit the complete range of pump sizes. Since parts for only two sizes of bearing brackets are required, regardless of the number of pumps operated, parts inventories are greatly reduced. All bearing bracket parts of R-9 pumps are interchangeable and all R-12s are interchangeable. Where continuous operation is vital, a complete spare assembly can be kept on hand and replaced very quickly.

Refinery Pump

- ☆ **Specially designed for high temperature operation**
- ☆ **Choice of materials and stuffing box arrangements**
- ☆ **Ample provision for cooling**

HERE IS AN ENTIRELY NEW refinery-type pump. It has every feature designed for continuous trouble-free service and to keep your process pumping costs low.

Sealing Arrangement

When the standard stuffing box is used, it carries an adequate amount of packing plus a seal cage. A mechanical seal is interchangeable with the packing. No machining required. A seal plus auxiliary stuffing box may be installed by simply cutting off the end of the standard stuffing box.

Cooling Methods

The stuffing box is cooled by a water jacket of ample capacity. Further cooling of the packing is provided by in-and-out connections for the sealing oil, which is thus able to act as a coolant as well as a sealing medium. The stuffing box is provided with a water-flushed smothering gland. A second water jacket surrounds the front bearing and the lower part of the oil reservoir. For extremely high temperature operation, a water-cooled pedestal can be supplied.

Throat Bushing

A renewable throat bushing is tack-welded on the pump side of the stuffing box. The close clearance between the bushing and the shaft sleeve cuts infiltration into the stuffing box to a minimum. In case of seal or packing failure, the bushing remains in position and will not blow out.

Wearing Rings

The impeller and casing are both provided with front and rear wearing rings which make it easy and economical to maintain proper clearance. This design also reduces side thrust which in turn reduces shaft deflection and wear.

Double Volute

Double volute design is used in pumps of more than 400 gpm capacity. Forces set up in one volute are counteracted by equal and opposite forces in the other volute. Deflection forces are greatly reduced.

The impeller has low NPSH requirement so that it will successfully handle high volatile liquids at high temperatures.

Centerline Mounting

The pump is mounted at the centerline of the casing. Pipe strains are transmitted directly to the foundation. When proper precautions are taken, alignment of rotating parts will not be affected.

Complete Pumping Unit

Allis-Chalmers can supply a complete pumping unit — pump, motor and control — assembled and ready to install. Coordinated design and manufacture assure undivided responsibility. Call your nearby Allis-Chalmers District Office for help on your next pumping problem. Or write for Bulletin 52B7775. Allis-Chalmers, Milwaukee 1, Wis.

A-4031

ALLIS-CHALMERS

HELP NEW Cracking Methods

LEFT: Catalyst lift air blower supplies air at 13,320 cfm, 4.25 psig to raise regenerated catalyst to reactor. Kiln combustion air blower is seen to the rear.

ABOVE: Carbon is burned off the catalyst while air is supplied at 34,400 cfm, 3.5 psig by this kiln combustion air centrifugal blower.

As cracking methods improve, more centrifugal blowers are being employed. The Allis-Chalmers single stage blowers seen here are essential to the three new Thermofor Catalytic Cracking units installed by the Magnolia Petroleum Co. at Beaumont, Texas.

A total of six turbine-driven A-C single stage blowers provide kiln combustion and catalyst lift air in the blower room of the new catalytic structure.

The high efficiency impellers are of special totally enclosed, backward flow design. This covered design makes the impellers independent of tolerance variations; the backward flow design gives good pressure, volume and horsepower characteristics.

High strength and long life is assured by all-welded, alloy steel impeller construction and pressure lubricated sleeve and thrust bearings. Cast iron casing increases rigidity and decreases noise level.

For this kind of specialized design . . . or for standard high quality, thoroughly tested air and gas handling equipment . . . call your nearest A-C office or write to Allis-Chalmers, Milwaukee 1, Wis.

A-3999

Texrope is an Allis-Chalmers trademark.

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Power, Electrical, Processing Equipment for Petroleum Industry

TURBINE-GENERATORS | BLOWERS and COMPRESSORS | TRANSFORMERS | UNIT SUBSTATIONS | MOTORS—TEXROPE DRIVES-CONTROL | CENTRIFUGAL PUMPS

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One-Cote Cement

INSULATES PROTECTS FINISHES

in one quick application

ONE APPLICATION saves valuable man-hours! Whether equipment is hot or cold (above 32 F), your crew simply trowels on the white, clean-handling cement to get a smooth, light-reflectent insulating surface.

ONE APPLICATION assures high thermal efficiency at temperatures up to 1000 F. One-Cote Cement sets quickly—and when installed indoors requires no finishing treatment. In outdoor installation, a weather-protective coating is recommended.

For a cement that INSULATES—PROTECTS—FINISHES in one application, you owe yourself a thorough investigation of Eagle-Picher One-Cote. For example, one of the many plus advantages you will value is its rust-inhibitive quality—it actually protects your valuable equipment. Get *all* the facts, today!

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LIMITORQUE REMOTE CONTROL

One man can operate any number of Valves, at any distance, from a push button station centrally located.

A Philadelphia Engineer will gladly call and help you with your valve operating problems. Write us now.

Limitorque makes possible the centralized operation of valves in remote or hazardous locations from convenient and strategically placed control panels. Thus, vital refinery and pipe line operating procedure can be handled by key employees, and is not dependent upon brawn alone.

Limitorque opens and closes any type of valve quickly and dependably. Valve stems, seats, discs, plugs and gates are fully protected from damage during closing cycle by the torque limiting mechanism. There are *many* exclusive design and construction features in Limitorque Controls, which are reasons for the world-wide preference for these "proved" Valve Operators.

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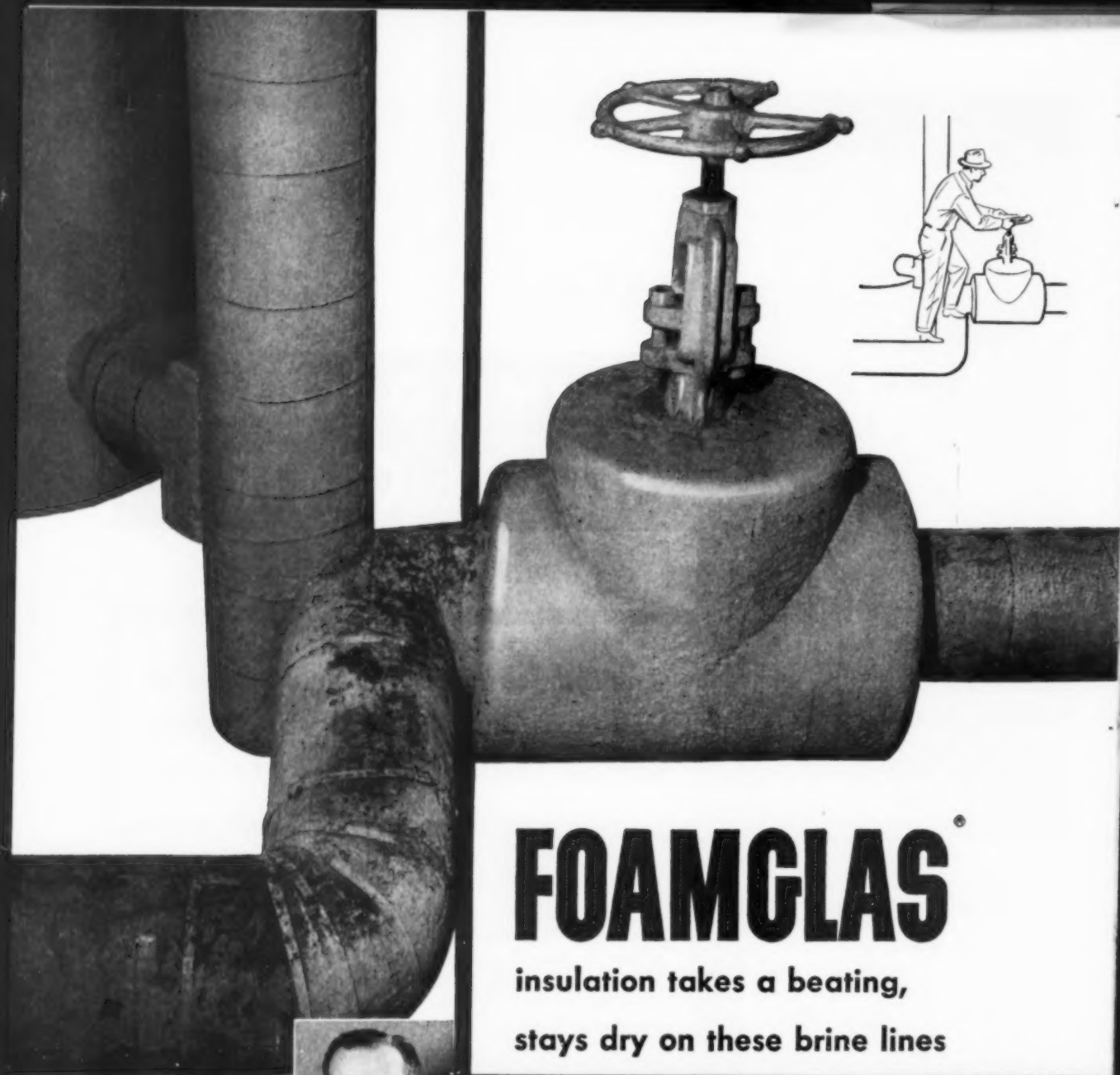
Industrial Gears and Speed Reducers
LimiTorque Valve Controls



FOAMGLAS®

insulation takes a beating, stays dry on these brine lines

C. E. Wolf

"Even such unavoidable abuse as being stepped on repeatedly for five years hasn't hurt this FOAMGLAS pipe insulation a bit," reveals C. E. Wolf, manager of the Natrium, W. Va., plant of Columbia-Southern Chemical Corp.

Mr. Wolf points out other benefits they get from this *cellular* glass insulation: "Condensation caused deterioration of the insulations previously used on our refrigerated brine lines, made repeated replacement necessary, and endangered the pipes with corrosion. After tests proved to us that FOAMGLAS would *stay dry* on these lines, preventing costly corrosion and maintenance, we standardized on it for all insulation replacement."

FOAMGLAS can solve *your* plant insulation problems, too. Please mail us the coupon today, and we'll send you full details covering your specific needs.

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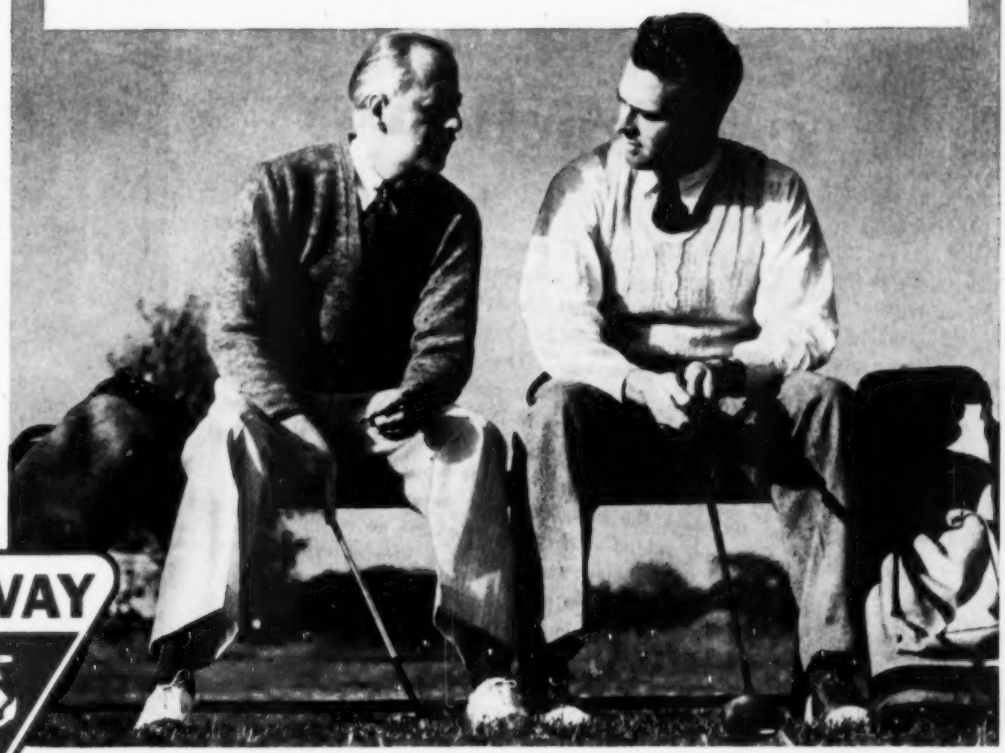
"I Call SOLVAY *FIRST* for Alkalies because...



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SOLVAY CHEMICALS FOR THE PETROLEUM INDUSTRY

Soda Ash
Caustic Soda
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Calcium Chloride
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...**I know** I can count on Solvay to give me the services I need to operate my business smoothly. Whether I'm placing a big order, or whether I want some technical help, I always get cooperation from the folks at Solvay.

A perfect example of this is Technical Service. Through the years, Solvay has accumulated a vast store of technical information that has been put into informative booklets called Solvay Technical Service Bulletins. These bulletins are available to me whenever I need 'em. And they cost me nothing—they're free. I can also get further technical help from the Solvay Technical Service staff—fellows who are experts in individual industries.

Doing business with Solvay is convenient for me, too . . . there are thirteen sales offices in key cities where you can get courteous friendly service. And you can get prompt delivery from Solvay's three centrally-located plants and more than 200 local stock points.

Why don't you call *Solvay first* for alkalies?"

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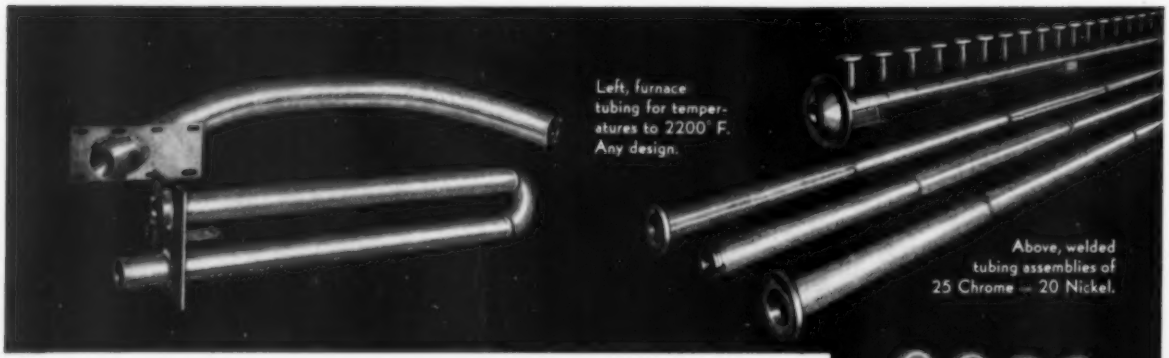


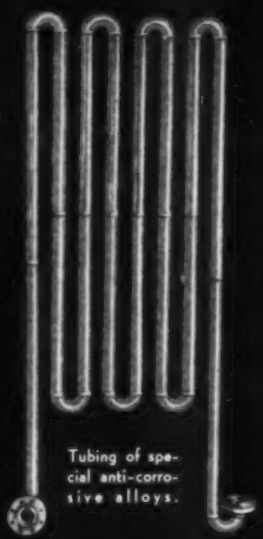
Left, furnace tubing for temperatures to 2200° F. Any design.

Above, welded tubing assemblies of 25 Chrome — 20 Nickel.

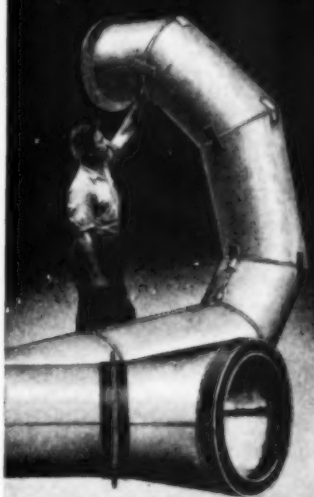
Cut Your Tubing Costs 3 Ways with PSC 'Thin Wall' Construction

Some customers have found that PSC process piping has cut their costs over 50%. Take for example a company which had been using 3" tubing of standard I. P. S. .216" wall thickness, on an application where pressure and erosion were low, but temperature and corrosion conditions were constantly troublesome. They installed PSC tubing of only 16 gauge (1/16" section) but of a metal analysis suited to solve their troubles. The saving in metal in this case was over 71%. At the cost of alloy steels, this was very substantial. But this customer saved two other ways also: In the lower fabricating cost of light gauges. And, lastly, in the less labor and material required to install PSC light-weight welded alloy tubing. We have no record of the replacement saving they are now enjoying. But the life/cost ratios of PSC process tubing are impressive. PSC process piping is furnished in any diameter up to 60" and in any alloy. We specialize in precision fabrication of complex tubing assemblies.

Send for Process Equipm't CATALOG 52



Tubing of special anti-corrosive alloys.



PSC light-weight welded alloy tubing facilitates construction problems in handling gases.

THE PRESSED STEEL COMPANY
of WILKES-BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

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A TESTED PROCESS FOR ETHYLENE OXIDE

LUMMUS *Presents*

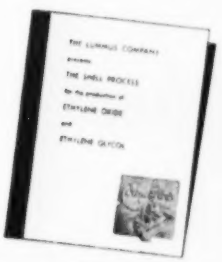
THE NEW SHELL PROCESS FOR THE PRODUCTION OF ETHYLENE OXIDE AND ETHYLENE GLYCOL.....

Now available through The Lummus Company are the Shell Development Company's processes for manufacture of ethylene oxide by direct oxidation of ethylene, and ethylene glycol by the hydration of the ethylene oxide.

At least five features of this Shell Process are particularly noteworthy:

- complete pilot plant testing has been done
- high yields result in optimum manufacturing costs
- unique instrumentation keeps all unit operations under close control
- waste disposal problems are considerably minimized
- unamortized product costs range from 8 to 10 cents per pound for ethylene oxide and 6½ to 8 cents per pound for ethylene glycol

Lummus is now prepared to design, engineer and construct Shell Process ethylene oxide and ethylene glycol plants —combining these features with Lummus' more than fifty years of experience in plant design and construction.



More details? Valuable information on ethylene oxide and ethylene glycol by the Shell Process has been developed by Lummus. Would you like a copy of this 12-page report? There's no obligation. Just drop us a note at Room 359, 385 Madison Avenue, New York 17.

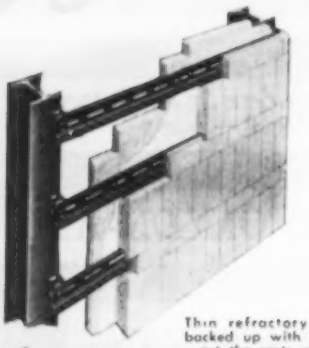
THE LUMMUS COMPANY

385 MADISON AVENUE, NEW YORK 17, N. Y.

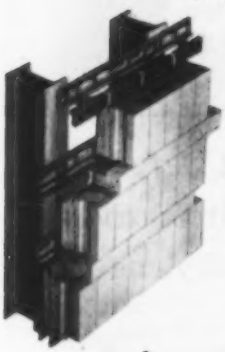
HOUSTON • CHICAGO • LONDON • PARIS • CARACAS

DESIGNING ENGINEERS AND CONSTRUCTORS FOR THE PETROLEUM AND CHEMICAL INDUSTRIES

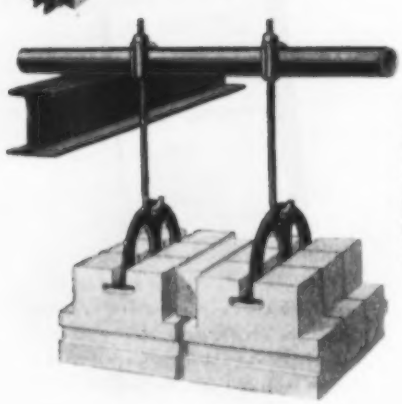
Heavy-duty B-L linings reduce oil still repairs



Thin refractory walls—backed up with insulation—cut the costs of oil still installations. When tile are shaded by tubes, 3" walls are used, 4½" walls are specified for exposed walls of moderate temperatures.



When the going is really tough, B-L engineers select rugged 7" walls. Unit-suspended B-L walls eliminate cumulative loading and expansion. Repairs are to damaged tile, adjacent areas are untouched

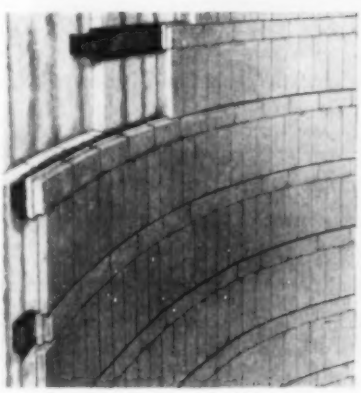


This pendulum-type Bigelow-Liptak arch permits the tile to swing freely in four directions. There is no cumulative loading or expansion thrusts against side walls. Arches are available in any thicknesses, follow any contour. Radial noses are similar.

Repairs are made quicker and at a much lower cost when oil stills are lined with Bigelow-Liptak walls and arches. Because heavy-duty refractories and insulation are used throughout, B-L linings stand up under the toughest of operating conditions.

Refinery boilers are enclosed with special applications of the same type of construction outlined above. When tubes are closely spaced, Bigelow-Liptak's new tube-supported wall is used. Both oil stills and boilers are covered with B-L's casing—TEXAD*. This new covering method is weatherproof, looks better, and replaces steel plate.

Catalogs describing refinery furnaces, the tube-supported wall, and TEXAD* are available upon request. Write today



Here is a Bigelow-Liptak wall curved to fit a 25-foot diameter vessel lining. It is backed up with insulation and is hung from modified circular brackets. B-L walls and arches can follow any furnace contour.

*TRADEMARK

BIGELOW-LIPTAK Corporation

and Bigelow-Liptak Export Corporation

2550 W. GRAND BLVD. • DETROIT 8, MICHIGAN

UNIT-SUSPENDED WALLS AND ARCHES

In Canada: Bigelow-Liptak of Canada, Ltd., *Toronto, Ontario*

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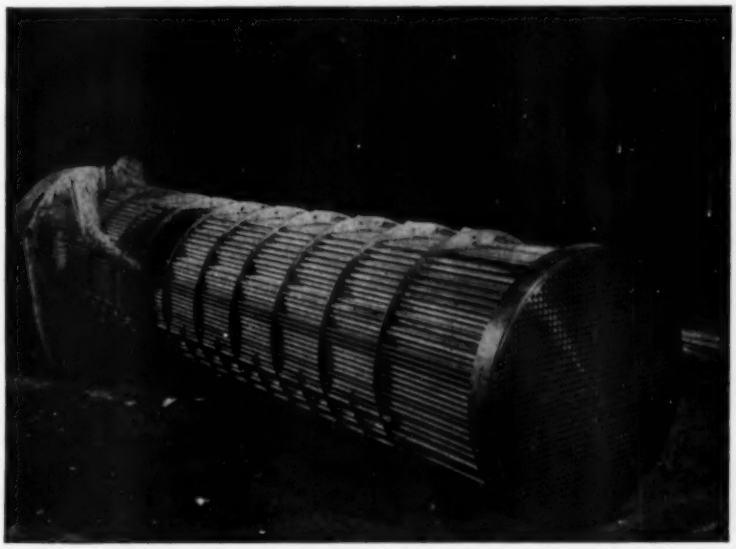
PROCESS EQUIPMENT NEWS

PUBLISHED BY FABRICATED PRODUCTS DIVISION, THE M. W. KELLOGG COMPANY JULY 1953

Exchanger Shops Altered to Handle Increased Demands of Chemical Industry . . .

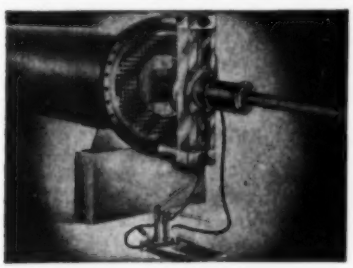
For many years, Kellogg's Exchanger Fabricating Shops in Jersey City concentrated on supplying exchangers for Kellogg's many refinery construction jobs and for making critical exchangers for specific outside customers. However, during World War II the facilities were expanded to produce exchangers for a host of marine and general chemical applications, as well as to handle business from other contractors. Since then this general demand has continued to increase . . . and the Shops have just been rearranged to insure prompt deliveries.



Nearly 200 Stainless Exchangers Completed in Less Than 18 Months

This stainless steel tube bundle, being inspected prior to insertion in its stainless-clad shell, is one of 187 such exchangers recently completed by Kellogg for a huge new chemical plant. The last unit was shipped less than 18 months after the order was received.

While there were minor variations in designs, the illustrated unit is typical of the exchangers involved. Carrying twenty foot long tubes and measuring almost 48 inches in diameter, it will handle highly corrosive materials. The tubes are of type 316 stainless and the tube sheets and baffles are of type 304. The shell is stainless-clad.



Hydro-Ejector Operates in Number of Refineries

Shown here is the new Kellogg portable Hydro-ejector now in use by a number of refiners and chemical plant operators. The Hydro-ejector removes and inserts the largest bundles with ease . . . eliminates costly steel work to support conventional methods.

Condenser Bundles Prove Precision Line-Up of Tube Sheets and Baffles Essential

Undesirable stresses can readily be built-into any exchanger during fabrication if tubes do not slide through baffles and into tube sheets with ease.

Only with precision line-up prior to inserting tubes is it possible to insure that the tubes will enter the bundle without use of excessive force.

Kellogg's close tolerance machining of tube holes and painstaking line-up make the insertion of tubes a relatively easy task in the fabrication of this propane condenser bundle. When complete it will contain 889 admiralty tubes. Baffles are of naval brass and approximately 33" in diameter.

For further information, details of methods, etc. contact

FABRICATED PRODUCTS DIVISION
THE
M. W. KELLOGG
COMPANY
225 Broadway, New York 7, N. Y.
or offices in Jersey City, Buffalo, Los Angeles, Tulsa, Houston, Toronto, London & Paris

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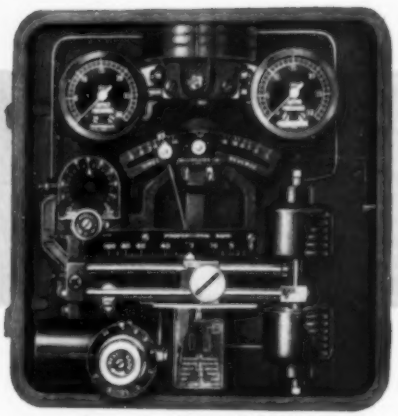
NEW MASONEILAN 12000 SERIES

Offer Accurate, Sensitive,

New Ease of Selection;

Proportional Controller



Proportional-Reset Controller

These new controllers reflect a realistic blending of past experience and current design trends, combining advanced features which reduce weight, improve adjustability and increase ease of selection, installation and servicing.

Consider what these design improvements can mean to you . . .

UNIT CONSTRUCTION

Unit subassemblies of the control mechanisms (proportional, or proportional-reset, unit and level setting mechanism) are mounted on the mechanism bracket which is in turn rigidly attached, piloted and doweled to the torque tube housing. Thus, individual units are fixed in position, unaffected by possible distortion of the case, yet are readily removable for servicing or interchange. Other sub-assemblies (pilot and manifold) are mounted in the rugged aluminum case which is finished and gasketed for outdoor service. Cover is closed by a positive cam-type latch.

SIMPLE AIR CIRCUITS

The high-capacity, balanced, amplifying, pilot with frictionless floating-action valve and cleanable sapphire orifice, is connected to the forged brass manifold which contains most air passages. Tubing in the proportional controller is limited to two short lines. The nozzle is easily removable for cleaning, and after replacement requires no aligning. Special ring type adapters facilitate connections.

EASE OF ADJUSTMENT

Proportional band setting . . . is made on a rod-type cantilever spring by a self-aligning clamp tightened by a large knurled knob located in front of the mechanism. A four-inch direct reading scale indicates the setting.

Control action and specific gravity setting . . . are selected by attaching the control link to desired side of reversing arc along the specific gravity scale, graduated from 0.5 to 1.4. The arc is easily reversible when instrument mounting is changed to opposite side of displacer.

Set point . . . is precisely adjustable throughout entire range by turning setting knob over 270° arc scale, 2″ long. Scale is reversible when control action is changed.

Direct level indication . . . is provided by a sturdy pointer fastened directly to the torque tube rod. The scale is graduated for both left and right hand instrument mounting and for several specific gravities.

FOR A WIDE VARIETY OF APPLICATIONS

LIQUID LEVEL CONTROLLERS . . .

Dependable Control – plus

Adjustment and Servicing

Top and bottom connections — integral chamber

Side and bottom (or side and side or side and top) connections — two-piece chamber (to permit field orientation of instrument)

Alignment micrometer . . . is sturdily mounted, is readily accessible and permits adjustments with minimum disturbance.

VERSATILITY

The proportional controller . . . may be used as a *Transmitter* and can be converted in the field to a

Differential gap controller . . . by simply reversing position of the coil spring and bellows in the proportional unit; or

Proportional-reset controller . . . by interchanging the proportional unit and the proportional-reset unit.

STURDY, COMPACT, ACCURATE MEASURING UNIT

All parts of the *Torque Tube Assembly* are made of a single alloy, individual parts being welded to form an integral unit. Knife-edge bearings support both ends of torque tube. Torque tube housing is removable from mechanism chamber.

Stainless . . . steel tubing *Displacers* designed so that standard control mechanism can be used for all ranges, are attached to the torque arm by hangers with modified-knife-edge hooks. Hanger extensions may be integral or detachable.

Chamber . . . assemblies are compact and light in weight to facilitate handling and installation. Mounting dimensions are uniform for all materials and ratings — and are in whole numbers; on side-mounted types mounting dimensions equal level range.

VARIETY OF TYPES, MOUNTINGS, MATERIALS

Instrument Types include *Proportional, Proportional-reset, Differential Gap Controllers* and *Transmitters;* or any combination of two of these in larger case. *Mounting Types* include top and bottom, side and side or side and either top or bottom, with screwed or flanged connections; also top or side of vessel with flanged connections. Instrument mounting left or right of displacer.

Ratings up to 2500 lbs. ASA.

Materials include iron (14″ & 32″ only), steel or alloy chambers; stainless steel displacers; inconel (or wide selection of other materials) torque tube assemblies.

Ranges — 14″, 32″, 48″, 60″, 72″, 84″, 96″, 120″

Complete details sent on request. Address

ALL HIGH Quality Confident PRODUCTS

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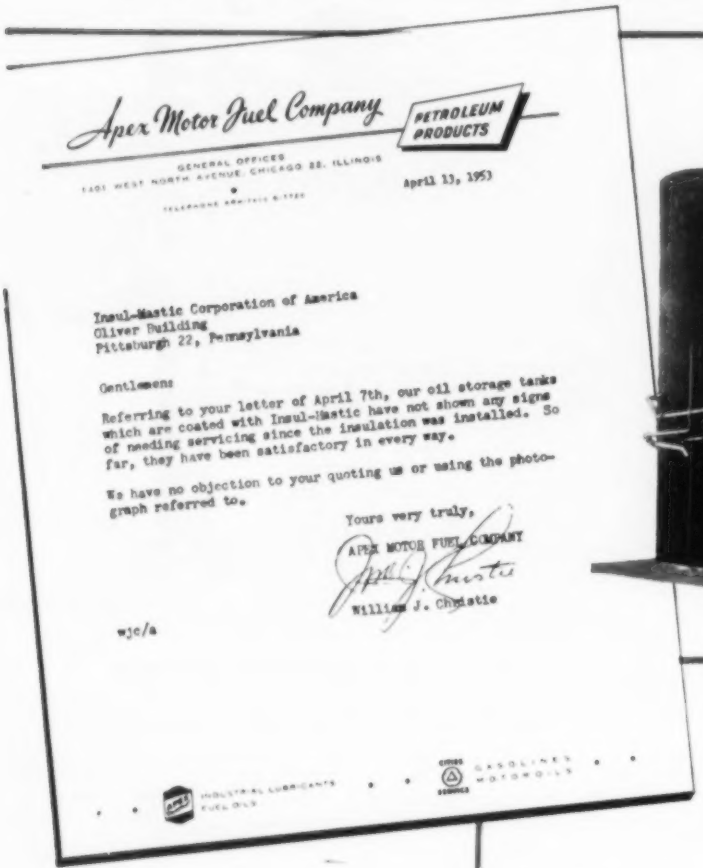
IN THE PROCESS INDUSTRIES

HERE'S PROOF OF THE LONG LIFE OF INSUL-MASTIC COATINGS



Apex Motor Fuel Company — PETROLEUM PRODUCTS

GENERAL OFFICES
1401 WEST NORTH AVENUE, CHICAGO 22, ILLINOIS

April 13, 1953

Insul-Mastic Corporation of America
Oliver Building
Pittsburgh 22, Pennsylvania

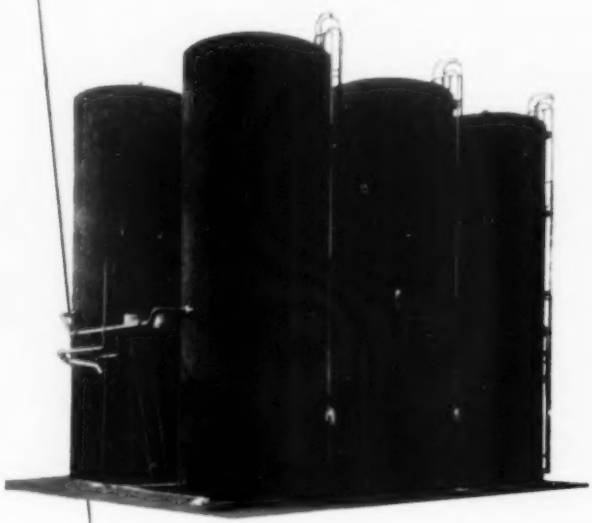
Gentlemen:

Referring to your letter of April 7th, our oil storage tanks which are coated with Insul-Mastic have not shown any signs of needing servicing since the insulation was installed. So far, they have been satisfactory in every way.

We have no objection to your quoting us or using the photograph referred to.

Yours very truly,
APEX MOTOR FUEL COMPANY
William J. Christie

wjc/a



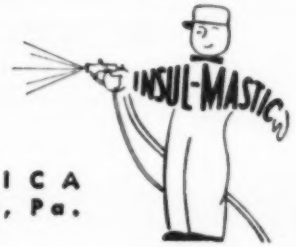
These heated, oil storage tanks referred to in the Apex letter have not needed anti-corrosion maintenance in 15 years. That's when INSUL-MASTIC TYPE "D" was applied to them. Many more years of protection are expected.

TYPE "D" coating contains granulated cork. It is applied ¼" thick in one coat and, besides preventing corrosion, it is a non-absorbent insulation which prevents about 65% of heat loss. This has meant a tremendous fuel saving for Apex during these 15 years.

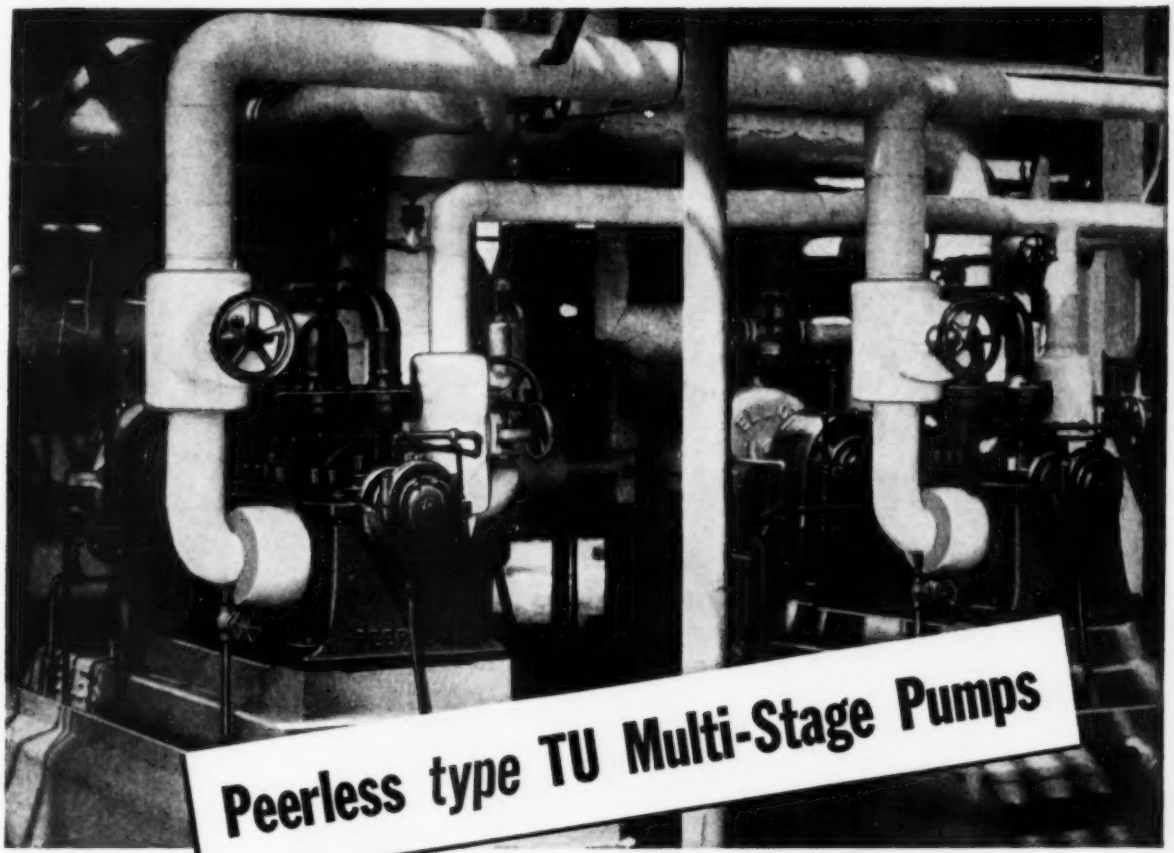
See your nearby INSUL-MASTIC applicator for preventing corrosion, insulating and vaporsealing insulation. Write for his name today.

Think first of the coatings that last!

For engineering assistance, call upon Insul-Mastic. Our technical staff will gladly advise on insulating, vaporsealing, corrosion prevention, weather sealing. Our experience in these fields is yours to draw upon.



Insul-Mastic
CORPORATION OF AMERICA
Oliver Building • Pittsburgh 22, Pa.
Representatives in Principal Cities



Peerless type TU Multi-Stage Pumps

PEERLESS PUMPS

GENERAL SPECIFICATIONS

HEADS	Up to 1600 Feet
CAPACITIES	Up to 3000 GPM
TEMPERATURES	Up to 300°F
CASE PRESSURES	Up to 800 Lbs.
HP RANGE	Up to 325 BHP
DRIVES	All Types
CONSTRUCTION	Cast Iron, Bronze, Stainless

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FOOD MACHINERY AND CHEMICAL CORPORATION
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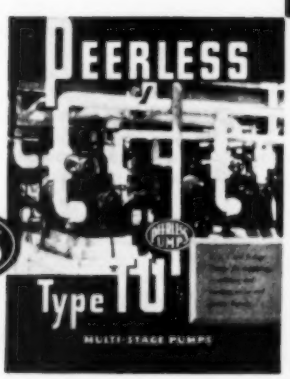
Offices: New York; Chicago; Indianapolis; St. Louis; Atlanta; Tulsa; Plainview and Lubbock, Texas; Fresno; Los Angeles; Phoenix; Albuquerque, New Mexico.
Distributors in Principal Cities; Consult your Telephone Directory

4 COST-SAVING FEATURES OF THE TYPE TU LINE

- *SIMPLICITY IN DESIGN*
- *GOOD HYDRAULIC CHARACTERISTICS*
- *DURABLE, RUGGED CONSTRUCTION*
- *ON-THE-JOB DEPENDABILITY*



2, 3, 4 AND 5-STAGE PUMPS FOR SUPPLYING CIRCULATING AND BOOSTING WATER AND PROCESS LIQUIDS AGAINST MEDIUM AND HIGH HEADS. Put these dependable pumps to work for you. They'll deliver high maintained efficiencies over an extended service life. Their split-case design makes them easy to service and maintain. Their precision construction guarantees year after year durability. In all sizes 4" and under, cross over between stages is built integral with upper pump case. Over-size shafts, wear rings, shaft sleeves, heavy duty ball bearings, modern case and impeller design are outstanding features. Choose from many types and sizes for all head and capacity requirements.

PROFUSELY ILLUSTRATED BULLETIN. A new 4-color bulletin describes the Peerless Type TU pumps. It's complete with pump cross-section, dimensional drawings and load-capacity data. Use coupon below.

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New BROCHURE!

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- Jacket Compounds
- Portable Cables
- Power Cables
- Control Cables
- Telephone Cables
- Tables

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The brochure shown above shows what "U.S." wires and cables to order for specific applications. Write to address below for your free copy.

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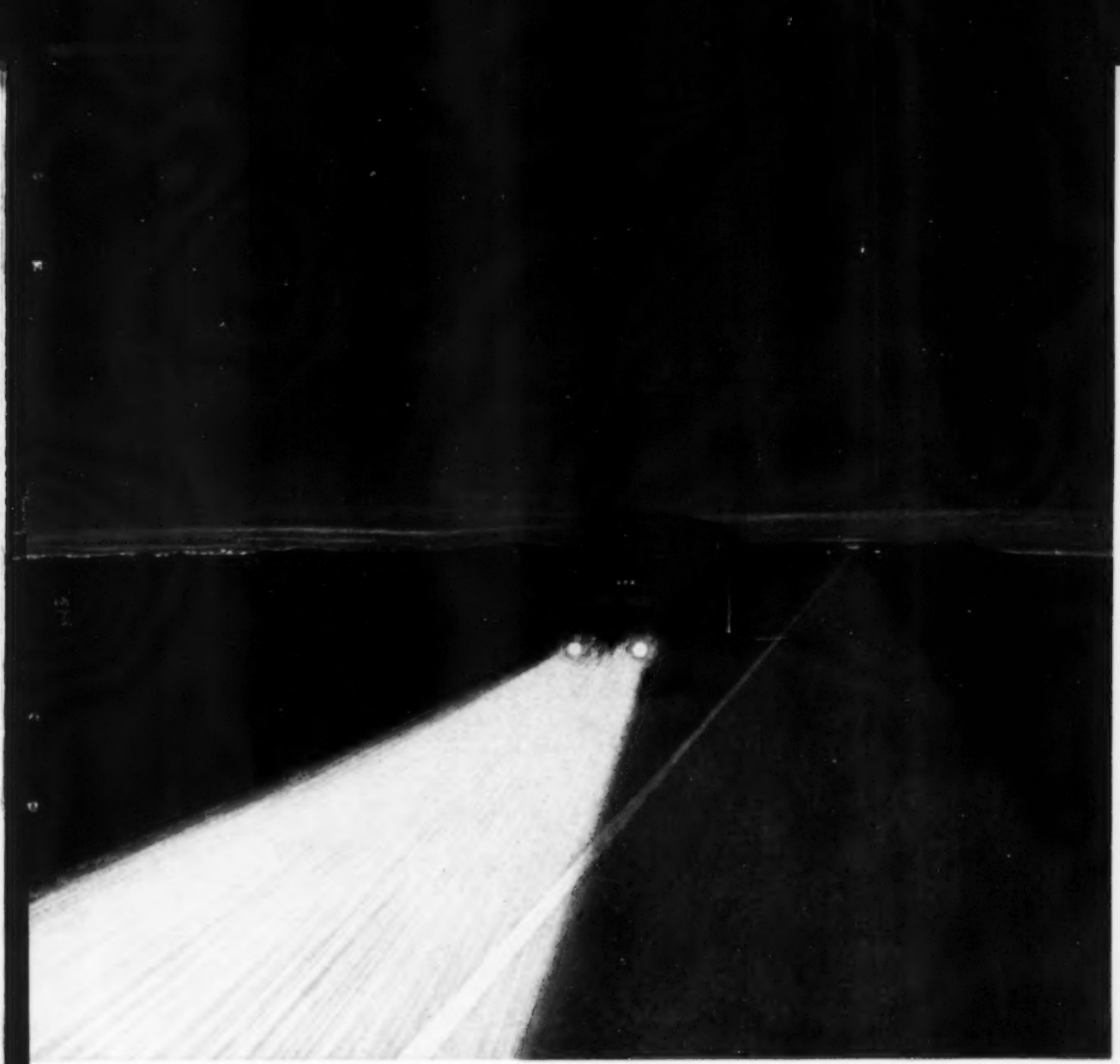

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Down the road.

Sometimes it takes millions of road-testing miles to be sure you've got reliable answers. That's why we think it is significant that since 1923 vehicles participating in Ethyl tests have rolled up more than one hundred million research miles.

Today at Ethyl's road-testing centers in Detroit and San Bernardino, both passenger cars and commercial vehicles of every representative type

(Continued on next page)

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100,000,000 miles looking for the answers

(*Continued from preceding page*)

are equipped with special test instruments . . . many of them devised by Ethyl research people. Every mile of every test is under the control of experienced engineers and technicians who understand thoroughly the problem of engines, fuels, and lubricants.

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And you can be sure they're out on the road today and every day piling up mileage in search of facts that will help you make and sell better petroleum products.

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They call it

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It's equipped with Rockwood Ball Valves

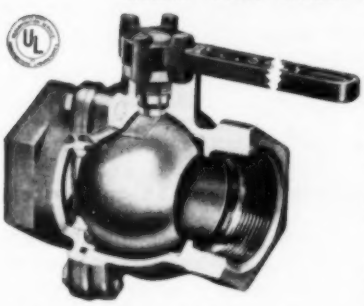
Carrying bottle gas in bulk over city streets is ticklish business.

But this large Transport Company made one decision and stopped a thousand worries. They equipped the fleet throughout with Rockwood Ball Valves. Not even the bumps of rough pavements or the jolts of quick stops and starts unseat these close-fitting valves.

Best part of it is, Rockwood Valves *stay* leak-proof. They resist wear, yet retain the quick-opening and closing features. They require no maintenance.

Rockwood Ball Valves handling "bottled gas" are operated every two minutes during the day. Tight seal makes them real production boosters and cost cutters.

WHAT YOU WANT . . . ROCKWOOD HAS



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Full Round Flow, with no change in shape or volume of the fluid and no turbulence. Minimum friction loss.

Quick Operation in opening and closing means faster loading and unloading.

Long Life, because made to resist abrasion and wear.

Low Maintenance because engineered to stand up under an anticipated daily grind.

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THE FLOW IS AS ROUND AS THE PIPE ITSELF

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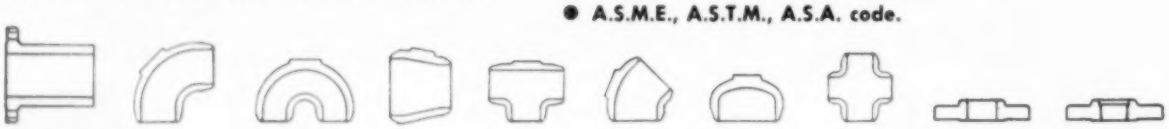
- **Greater wall thickness throughout—for increased structural strength.**
- ***Extra* thickness in critical areas—for greater allowance against corrosion and erosion.**
- **Controlled quality . . . through rigid metallurgical control . . . produced, inspected and tested in one plant.**
- **Low unit cost . . . plus prompt deliveries.**
- **A.S.M.E., A.S.T.M., A.S.A. code.**



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Key company

Since 1916 . . . manufacturers and developers of products for high temperatures and pressures

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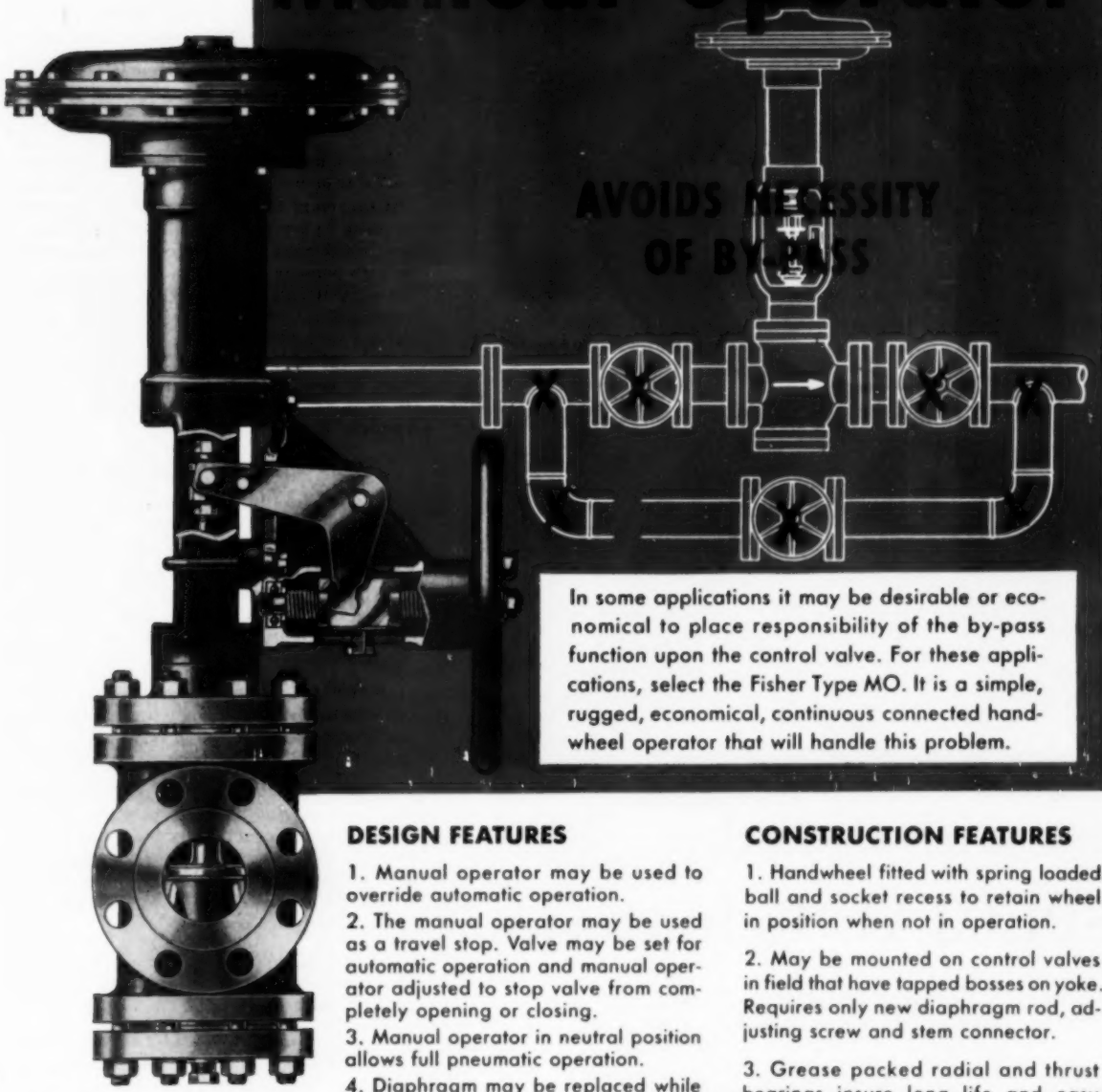
Type MO Manual Operator

AVOIDS NECESSITY OF BY-PASS



In some applications it may be desirable or economical to place responsibility of the by-pass function upon the control valve. For these applications, select the Fisher Type MO. It is a simple, rugged, economical, continuous connected handwheel operator that will handle this problem.

Fisher Type 57-T diaphragm motor valve with side mounted Type MO handwheel operator in section.

DESIGN FEATURES

1. Manual operator may be used to override automatic operation.
2. The manual operator may be used as a travel stop. Valve may be set for automatic operation and manual operator adjusted to stop valve from completely opening or closing.
3. Manual operator in neutral position allows full pneumatic operation.
4. Diaphragm may be replaced while manual operator is used to control flow of fluid.
5. Manual operator is mounted on side of control valve for accessibility and ease of operation.

CONSTRUCTION FEATURES

1. Handwheel fitted with spring loaded ball and socket recess to retain wheel in position when not in operation.
2. May be mounted on control valves in field that have tapped bosses on yoke. Requires only new diaphragm rod, adjusting screw and stem connector.
3. Grease packed radial and thrust bearings insure long life and easy operation.
4. Handjack operating screw constructed with pitch to give adequate operating power.

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To improve chemical processes or increase yields, get your answer from Norton.

No *one* refractory can be the solution to all your problems. But Norton Rx service will help you get the composition best suited to your particular purpose.

In almost every field of chemical processing, Norton Refractories are making definite contributions — improving methods and cutting costs. This is true in catalyst supports for the manufacture of phthalic anhydride, for reforming natural gas and production of "atmosphere gas" — electric furnace shapes . . . porous mediums, for filtration, diffusion and aeration.

To get your Rx in catalyst supports

Norton makes catalyst supports having *controlled* structure. Thus the Rx for rings and pellets can range from medium porosity to high porosity — for spheres from medium porosity with rough exterior for coating with a catalyst, to high porosity with a network of open pores throughout and rough exterior designed for impregnating with catalyst. Spheres are made in diameters ¼″ to 1″. Rings supplied from 3/32″ I.D., 3/16″ long, 7/32″ O.D. to ½″ I.D., 1″ long, 1″ O.D. Pellets from ⅛″ x ⅛″ to ½″ x ½″. Catalyst supports are just an example of Rx engineering.

The "Basic 4" for your Rx

According to the requirement your Rx is for ALUNDUM*, CRYSTOLON*, MAGNORITE*, or FUSED STABILIZED ZIRCONIA, each with its own particular characteristics. All are chemically stable . . . all are highly refractory, resistant to abrasion and have extra long life. Here are just a few of their uses in many fields.

Norton ALUNDUM catalyst supports in the manufacture of phthalic anhydride, production of "atmosphere gas" and in reforming natural gas.

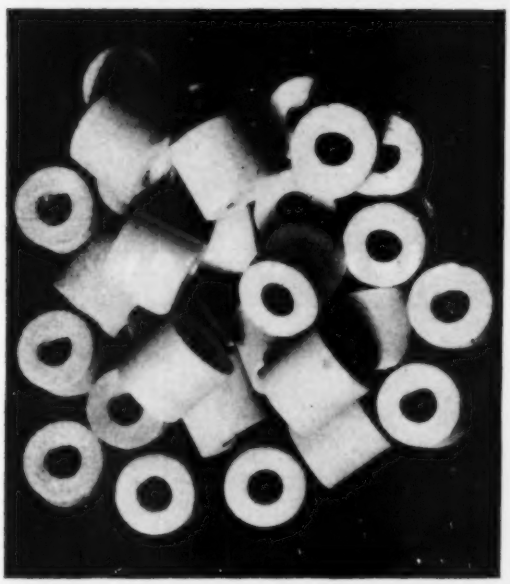
Norton FUSED STABILIZED ZIRCONIA has stood up under 4700°F in gas synthesis. Its low thermal conductivity and its high electrical conductivity at elevated temperatures make it useful for many special chemical processes. No other refractory is so chemically stable under high temperature.

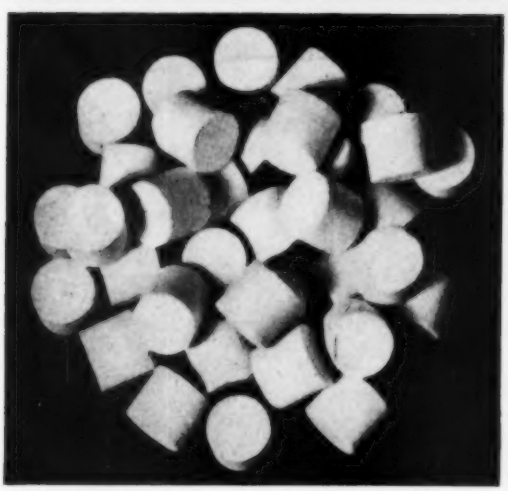
Norton ALUNDUM porous mediums with "controlled permeability" are ideal for filtration, diffusion or aeration.

Norton ALUNDUM, CRYSTOLON and MAGNORITE mixtures for reaction furnaces are supplied in a variety of shapes engineered to your exact requirements.

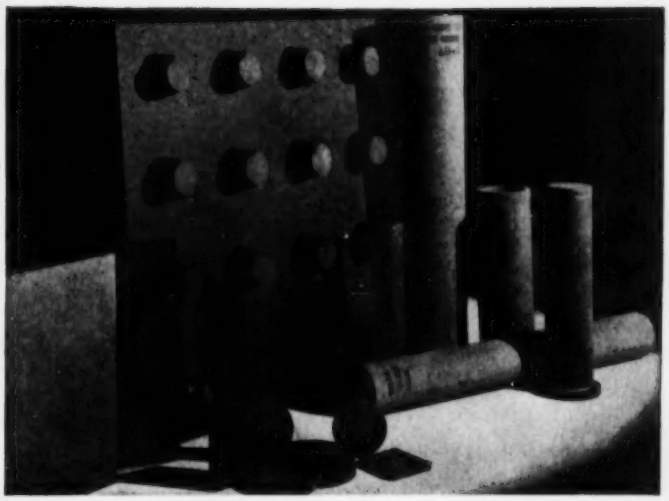
Find out more

So broad is Norton's range of Special Refractories that it can only be outlined here. We believe that it will pay you to make Norton Refractory Research your partner in solving your problems. For quick action, just contact your Norton Refractories Representative or write NORTON COMPANY, 466 New Bond St., Worcester 6, Mass.

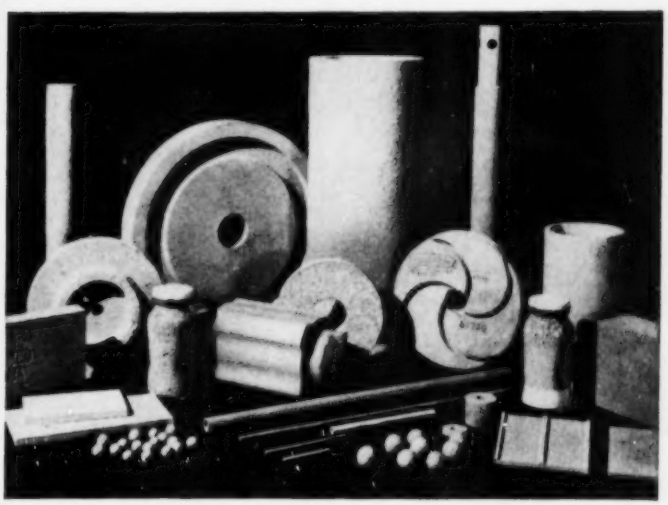




Norton catalyst supports are made in spheres, pellets and rings, by Norton's "controlled structure" process.



Norton ALUNDUM porous mediums come in plates, tubes, discs and diaphragms to fit your exact requirements.



Norton refractory shapes for reaction furnaces come in bricks, plates, tubes and blocks of ALUNDUM, CRYSTOLON, MAGNORITE and FUSED STABILIZED ZIRCONIA.

NORTON

Special REFRACTORIES

Making better products to make other products better

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

Master Fluid-Drive units make use of a fluid coupling so designed that it can be interposed easily between the motor shaft and the output shaft (or motor shaft and first stage of gears of a gear-motor). Use Master Fluid-Drive Motors and gain these advantages.

SMOOTH ACCELERATION. With the fluid drive, the load is gradually accelerated . . . no sudden jerk at starting.

FULL POWER. Since there is no load on the motor when it starts, it very rapidly attains full running speed and the duration of the starting current inrush is greatly reduced.

CUSHION EFFECT. Provides cushioned starting . . . protects motors, gears, and driven equipment from damage from severe shock loads.

WIDE APPLICATION. Fluid-Drive Motors are ideal for high inertia applications where it takes a long time to bring the load up to speed . . . for starting crane travel drives without jerking and swinging the load . . . for conveyor drives especially where they are handling fragile material . . . for agitators, textile machinery, presses, extruders, winding machinery, food machinery, laundry machinery, ball mills, calenders, machines, etc.

cushioned power

SIZES. Master Fluid-Drive Motors are available in sizes approximately ½ to 15 horsepower.

THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO

MASTER

FLUID DRIVE MOTORS

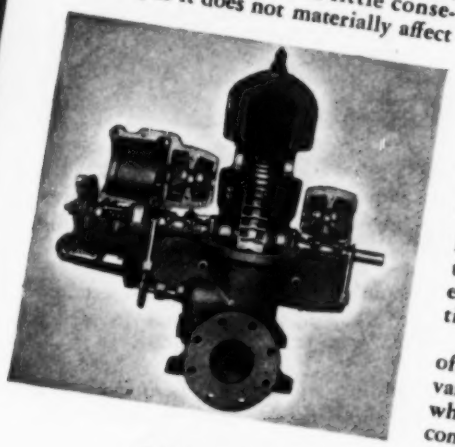
TERRY

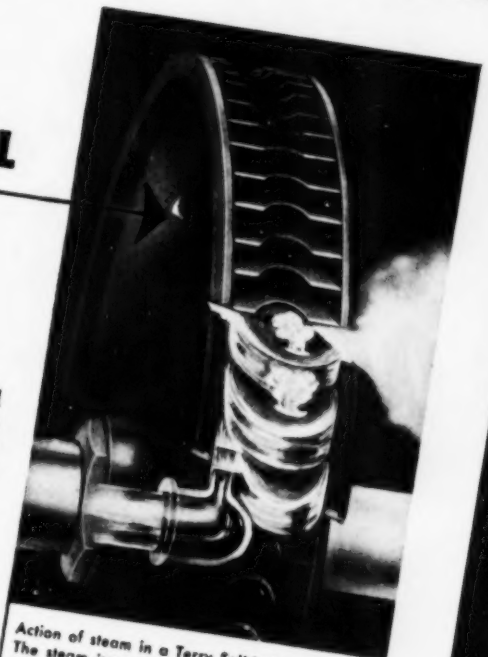
THIS TURBINE WHEEL

has no parts to loosen or work out

The rotor of the Terry Solid-wheel Turbine is a single forging of special composition steel, in which a series of semi-circular buckets is milled. There are no separate parts to become loose or work out.

The power-producing action of the steam takes place on the curved surfaces at the back of the buckets. Hence, wear of the blades is of little consequence, as it does not materially affect horsepower or efficiency. There is practically no end thrust since the steam enters and leaves the wheel in a direction at right angles to shaft.





Action of steam in a Terry Solid-wheel Turbine. The steam issues from an expanding nozzle at high velocity and enters the side of the wheel bucket where its direction is reversed 180°. As this single reversal uses but a portion of the available energy, the steam is caught in a stationary reversing chamber and returned again to the wheel. This process is repeated several times until practically all of the useful energy has been utilized.

This is only a small part of the story of the many advantages of the Terry Solid-wheel Turbine. Write for complete details.

THE TERRY STEAM TURBINE CO.

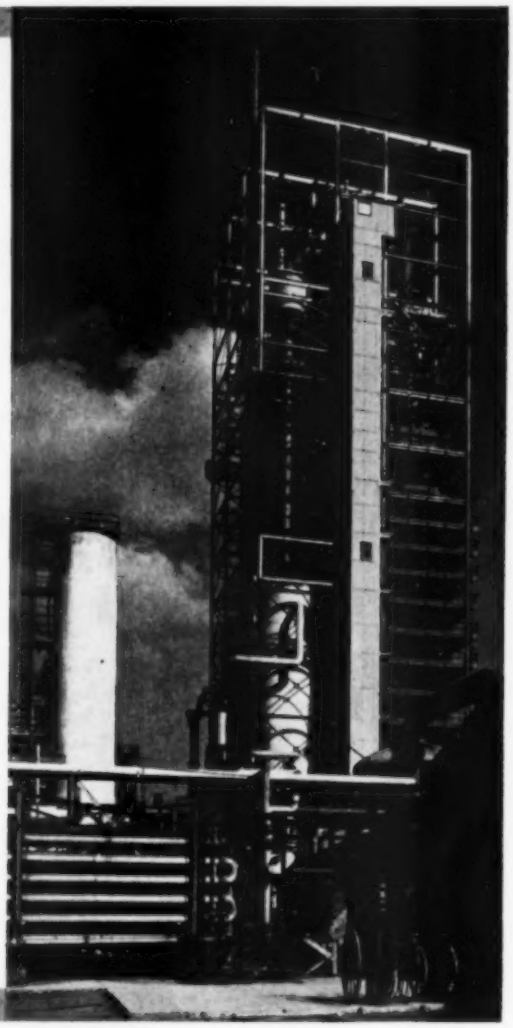
TERRY SQUARE, HARTFORD 1, CONN.

TT-1189

Memo

Send for a copy of bulletin S-116 which describes the many advantages of the Terry Solid-wheel Turbine.

Forty billion barrels ago—



Measured in years, it is less than a century since Colonel Drake drilled the first oil well, in 1859. Measured in terms of the gigantic American petroleum industry which grew from his pioneering enterprise, the August day when his well spurted forth the long-sought oil was more than forty billion barrels ago.

Two thousand barrels was the output in 1859. About two billion barrels now come yearly from American wells to meet the demands of the modern motor and the varied other uses of petroleum products.

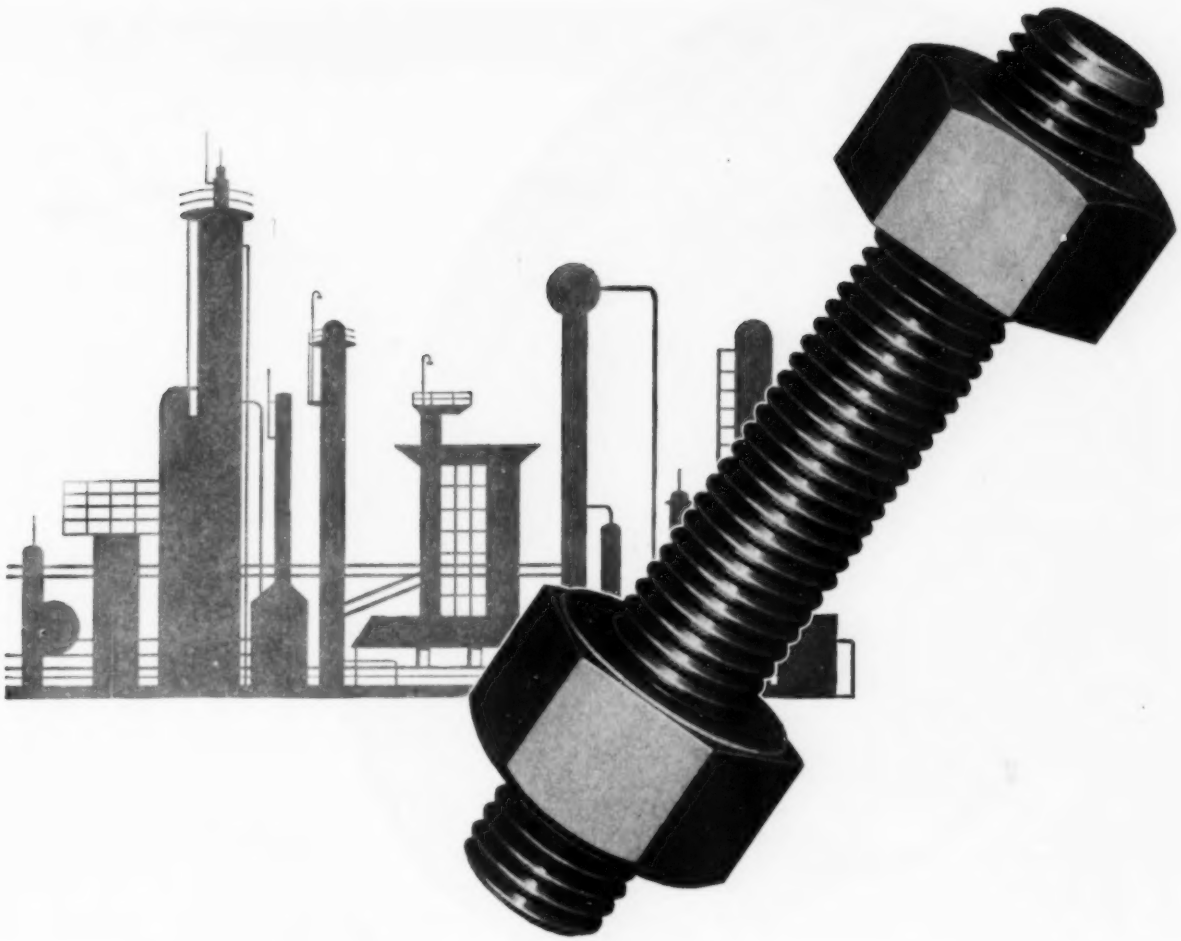
For decades, Sun Ship has played an important part in construction of the refinery equipment . . . fractionating towers, condensers, pressure vessels, machinery and other equipment . . . to meet these demands. The facilities, modern manufacturing methods and skilled personnel at the great Sun Ship plant provide a combination that has consistently shown its ability to serve the petroleum, chemical and petrochemical industries in the task of building a greater America.

Sun

SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE (SINCE 1916) **CHESTER, PA.**

25 BROADWAY • NEW YORK CITY



Stronger under heat and pressure . . . . . .

REPUBLIC UPSON ALLOY STEEL STUDS

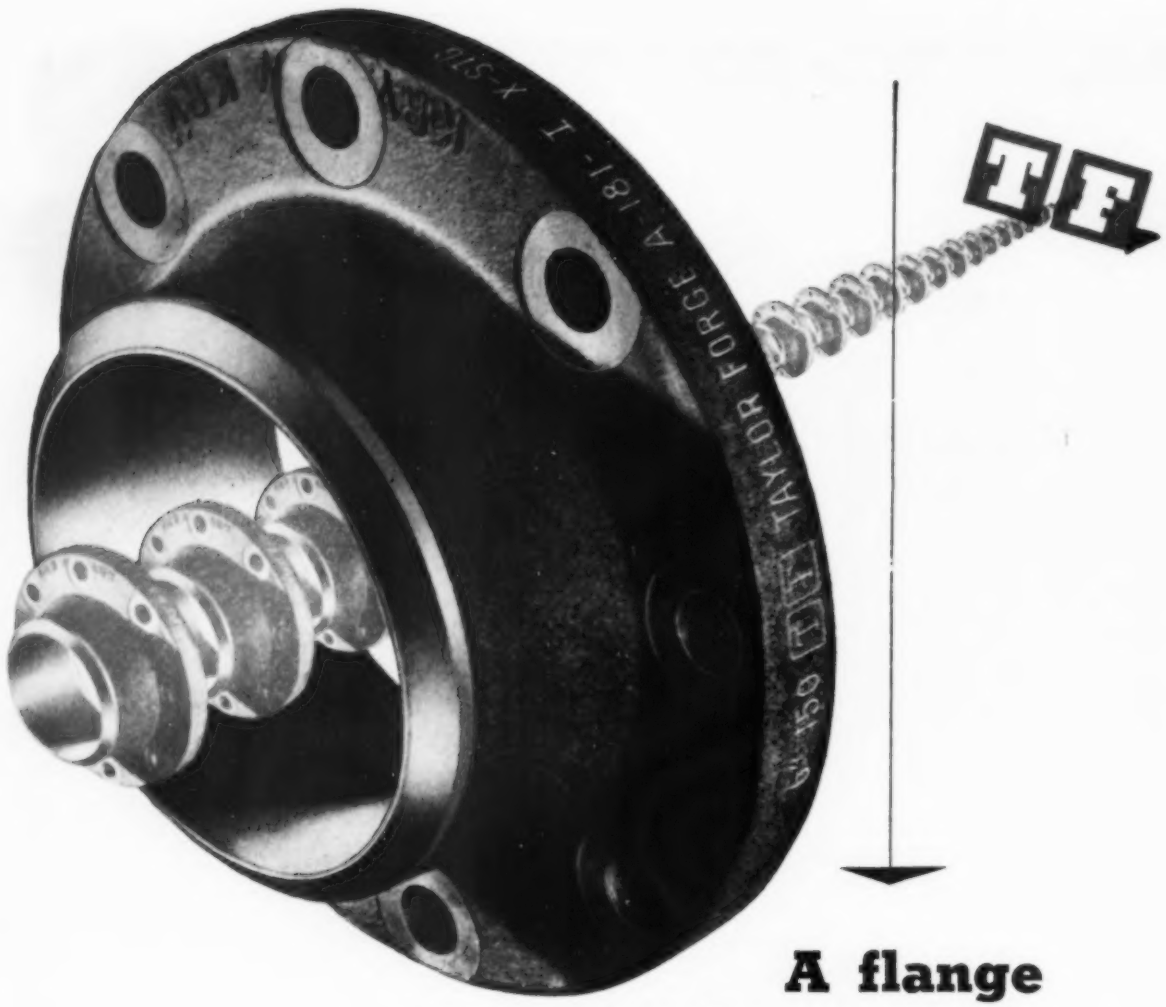
On high-pressure equipment in refineries everywhere, Republic Upson Alloy Steel Studs provide maximum holding power with minimum unscheduled replacements.

Uniform alloy structure gives these studs calculated strength that can be relied on; clean accurate threads assure full as-designed engaged thread area for maximum resistance to pull-out; strong square faces provide trouble-free tightening and back-off of nuts.

Specify Republic Upson Alloy Steel Studs for new pressure vessels . . . and as replacements on present pressure equipment.

REPUBLIC STEEL

REPUBLIC STEEL CORPORATION
Bolt and Nut Division
CLEVELAND 13, OHIO
Export Dept.: Chrysler Building, New York 17, N. Y.



A flange with a background . . .

You are looking at a flange with a history. Taylor Forge made the forged steel flange and in a sense the forged steel flange made Taylor Forge. It was Taylor Forge, back in 1905, who made the first forged steel flanges on a commercial scale . . . and it is Taylor Forge who has guided flange development across the past half century.

Through the first threaded flange form, the bolted Van Stone form, and the perfected welding neck form pictured here, Taylor Forge has undeniably contributed more to flange development than any other organization*.

Taylor Forge Welding Neck Flanges are a part of the WeldELL® line—the line that more than 20 years ago gave industry the first complete line of fittings for pipe welding. The organization that led development is still leading . . . in scope of types, sizes, weights, materials . . . in quality and downright value!

For up-to-the-minute facts see your Taylor Forge Distributor

TAYLOR FORGE

TAYLOR FORGE & PIPE WORKS, General Offices & Works: P.O. Box 485, Chicago 90

Plants at: Carnegie, Pa., Fontana, Calif., Gary, Ind., Hamilton, Ont., Canada

* When pressures rose from the old 150- and 300-pound standards to 400, 600 and finally 900 pounds, it was largely the exhaustive research of Taylor Forge that supplied the formulas for determining stresses in flanges for any given condition of loading. Among many examples: the Taylor-Waters formula, published in 1927, became and still is the basis of recognized practice for flanges in sizes through 24". Again, in 1938 Taylor Forge published the first edition of the now authoritative "Modern Flange Design" based on methods proposed by E. O. Waters, D. B. Rossheim, D. B. Wesstrom and F. S. G. Williams, Taylor Forge Manager of Engineering Standards. (ASME Trans., Apr. 1937)

507-0753

Part of the welding floor at Grinnell's Warren, Ohio Plant

How shop fabrication of piping

keeps costs down...quality up!

When you specify piping fabricated in Grinnell shops, you are ALL to the good.

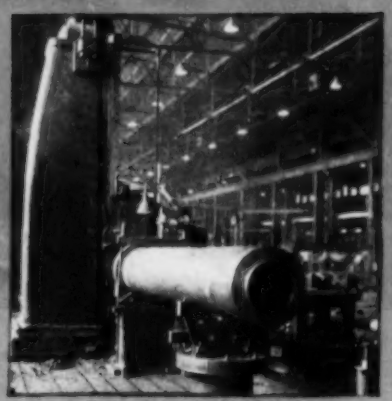
Here's why: — Included in the price (which is determined in advance) are such items of expense as:

- Interpretive engineering
- Shop sketches and planning
- Procurement of materials
- Heat, light, power, water, compressed air, expendable tools and supplies

But Grinnell even goes further. Grinnell finances material inventories and payrolls for you; carries insurance; makes no charges for waste material or spoilage.

On the production side, too, you benefit. Piping fabricated in Grinnell shops is done under ideal conditions, with modern equipment, by personnel qualified for each class of work. It is rigidly inspected and tested to meet customer's specifications and all applicable codes. Before shipment, it is cleaned inside and outside and painted. It is squared to dimensional tolerances, so that sub-assemblies can be erected at the job site quickly and easily.

You can count on it . . . Grinnell shop fabricated piping *guarantees* maximum quality and economy.



Heavy wall pipe being machined to the proper welding bevel on a pipe mill

Welding (induction heating coils in place for preheat, welding heat and stress relieving.)

GRINNELL

WHENEVER PIPING IS INVOLVED

Grinnell Company, Inc., Providence, Rhode Island • **Coast-to-Coast Network of Branch Warehouses and Distributors**

pipe and tube fittings • welding fittings • engineered pipe hangers and supports • Thermolier unit heaters • valves
Grinnell-Saunders diaphragm valves • pipe • prefabricated piping • plumbing and heating specialties • water works supplies
industrial supplies • Grinnell automatic sprinkler fire protection systems • Amco air conditioning systems

8-hour job now takes 4 hours

At a western magnesium reduction plant something besides magnesium has just been reduced. The steam at the end of the 1½ mile long steam line wasn't so hot—and neither was the production record of the plant at that location.

Then 26 old-type steam traps were replaced with Yarway Impulse Traps. Now there is only a 15° temperature drop from the boilers to the end of the line. *Most important, the plant 1½ miles from the boilers is now able to do work in 4 hours that previously took 8 hours.*

That's trap efficiency! It's evidence of the fact that Yarways are designed to send the most premium B.T.U.'s at top temperatures into your process or product. *They get equipment hotter, sooner . . . and keep it hot.*

Other Yarway features—small size, one moving part, easy installation, low maintenance, low cost, stainless steel construction. Nearly 750,000 Yarways have already been installed. For your Yarways, see a nearby industrial distributor . . . 216 stock and sell Yarways.

YARNALL-WARING COMPANY, 128 Mermaid Ave., Philadelphia 18, Pa.

FREE TRAP SELECTOR

It's important to have the right trap in the right place. New 20-page selector tells quickly and easily which *is* the right Yarway trap for any application. Write for your free copy.

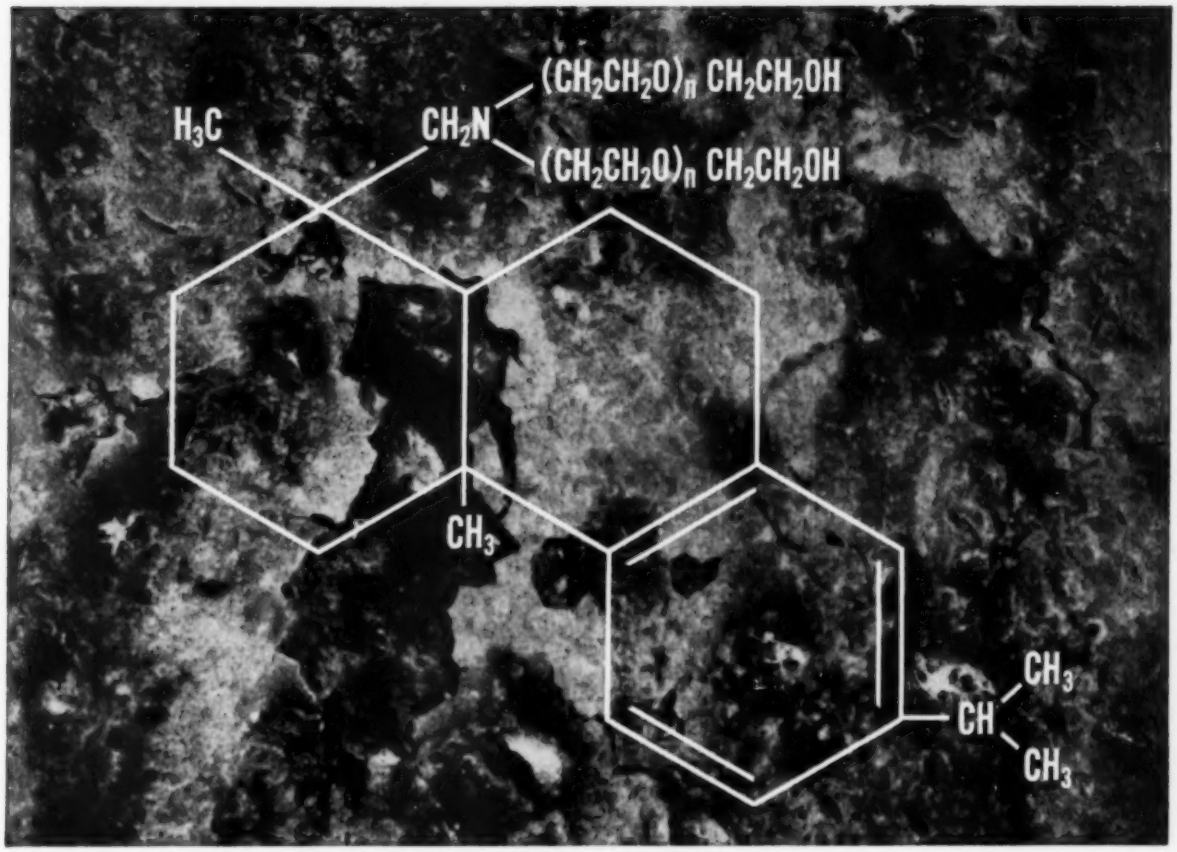
NEW STEAM TRAP MOVIE

"Please Pass The Condensate" is a new 20-minute, color film on steam trapping for more production. Write now to arrange a plant or group showing.

YARWAY

the steam trap

designed with more production in mind



ACID CORROSION IN REFINERIES CONTROLLED WITH POLYRAD

New Chemical Inhibitor Also a Detergent

Internal corrosion and plugging of refinery equipment are controlled with Polyrad 1110-A, a new inhibitor developed by Hercules research. Now in use in a number of refineries, Polyrad helps maintain throughput, increases heat transfer, reduces metal loss, and cuts shutdown time and repairs.

Polyrad is a derivative of an organic amine. Its chemical nature is shown above. When injected into refinery equipment, it forms a molecular film that shields metal surfaces from hydrogen-ion attack by organic and inorganic acids.

Polyrad 1110-A, used in refinery equipment, is unique in that it has a detergent action. It loosens iron sulfide and other scales, permitting them to be dispersed in the fluid stream and removed at the water separator or product receiver.

This new inhibitor is designed to function efficiently under acid conditions. For example, at low concentrations it gives better than 99 per cent protection to mild steel immersed in strong hydrochloric acid. It can also be used in conjunction with ammonia or other alkalies. Polyrad has proved to be effective up to 500°F.

Polyrad 1110-A is readily available. Stocks are carried at convenient locations for prompt shipment. For further information, send for Technical Service Bulletin No. 189.

Naval Stores Department

HERCULES POWDER COMPANY

INCORPORATED

976 Market Street, Wilmington 99, Del.

POLYRAD®

A Hercules Rosin Amine Derivative

NA53-1

Where Does It Hurt?

Throughput off . . . maintenance rising . . . costs up—where do you want the bandage? If the problem's in your equipment, see what you think of this approach.

A refinery wanted to cut cost of both distillation of sour crudes and production of lube fractions. The aim: Peak yield from sour crudes containing sulfides and organic chlorides . . . elimination of need for "select" crudes. The answer? Five clad steel combination atmospheric-vacuum distillation units providing maximum processing control.

These units assure peak yields with maximum efficiency and minimum equipment cost, through an intimate mixing of crude vapor with internal reflux oil as it comes through the caps. Vacuum operation reduces distillation temperatures to a minimum to avoid cracking and to produce fractions with good flash-viscosity relationship. Clad steel construction most economically combats corrosive effects of high-temperatures, sulphur, moisture and hydrochloric acid . . . assures long equipment life.

What approach leads to such advances? Combined planning by the staffs of progressive Equipment Builders, process engineers, designers and materials suppliers. Such builders turn to Lukens regularly for its knowledge of materials and its wide range of low-cost clad steels.

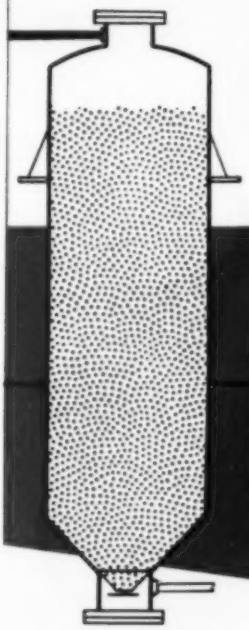
With new equipment hard to get these days, you might want such a builder to look into your equipment problem. For names of Equipment Builders who can help you, write us today, explaining your problem. Manager, Marketing Service, 404 Lukens Building, Coatesville, Pennsylvania.

LUKENS

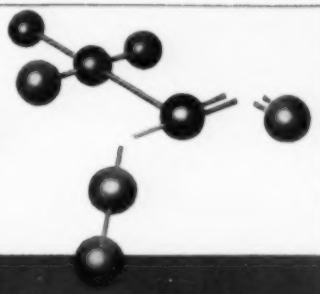
World's Leading Producer of

SPECIALTY STEEL PLATE • PLATE SHAPES • HEADS • CLAD STEELS

LUKENS STEEL COMPANY, COATESVILLE, PA.



...ready to tackle
any sorptive-mineral job
that comes along...



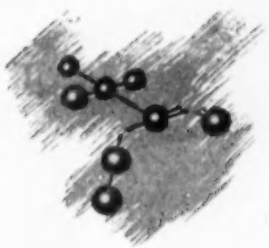
ATTAPULGUS Fullers Earth
POROCEL Activated Bauxites

ADSORBENTS

There's an Attapulgus or Porocel adsorbent to fit your process technique for removing odors, colors, tastes, moisture, acids, sulfur, fluorides and unsaturates from process liquids or gases. Materials treated in principal applications are: motor oils and other lubricating, specialty, and technical oils; petrolatums and waxes; aviation and motor gasoline stocks; kerosene; diesel and heating oils; chemicals and petrochemicals.

CATALYSTS, CATALYST CARRIERS

Our sorptive minerals are recognized standards in desulfurization, reforming and isomerization systems—catalytic removal of unsaturates—conversion of sulfides to elemental sulfur—fluid catalyst applications—as catalyst carrier in copper sweetening processes.



DESICCANTS

We offer a wide range of reliable, thoroughly proved desiccants for drying air, hydrogen, carbon dioxide, hydrocarbon liquids and gases.

SPECIAL GRADES

Mine and plant facilities permit prompt and economical production of grades meeting individual customer specifications. Our laboratories and technical staffs are ready to assist in research, development, design and operating problems. Your inquiries are invited.

ATTAPULGUS MINERALS & CHEMICALS CORPORATION · **POROCEL** CORPORATION

Dept. W, 210 West Washington Square, Philadelphia 5, Pa.

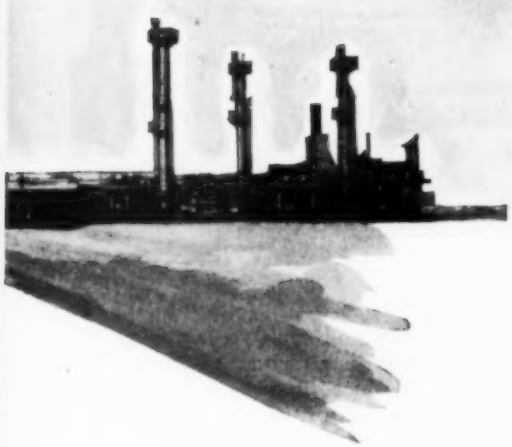
BUILT BY
PROCON
FOR
ROOSEVELT OIL
& REFINING CORP.

■ The completion of the new major refining units and outside facilities at Roosevelt's Mt. Pleasant, Mich., refinery adds another important installation to Procon's record of achievement. It also demonstrates the versatility of Procon's organization in handling a wide range of work.

NEW 3-UNIT COMBINATION

PLATFORMING
UDEX
PLATREATING

Procon participated in preparing erection drawings and handled the construction of all three units which were engineered and licensed by Universal Oil Products Co. Foundations were placed on piles because that part of the refinery is built on a seven-foot dirt fill.



Procon's field engineers also built a central control room with a large graphic flow panel. In addition, Procon workers built roads, erected an enclosure fence, assisted in the installation of transfer piping — all of which indicates the broad scope of Procon construction service.

PROCON *Incorporated*
PROCESS CONSTRUCTION
1111 MT. PROSPECT ROAD, DES PLAINES, ILL., U. S. A.

IN ENGLAND
PROCON (*Great Britain*)
LIMITED
112 STRAND, LONDON, W. C. 2

Installing another Struthers Wells Mixing Vessel for processing HEAVY VISCOUS MATERIALS

Struthers Wells

Double motion AGITATOR

A The double motion drivehead is an exclusive Struthers Wells design and is available in Horse Powers ranging from 2 to 150, and is furnished with proper sealing devices when it is used on pressure kettles.

B Kettles can be open flat top as shown or equipped with a dished and flanged or similar closed top suitable for working pressures as high as 300 lbs.

C Sweep and paddle arms are pitched to create a definite flow of material throughout kettle—preventing stratifying of mix. Scraper frame and paddle arms can be of welded design or bolted for easy removal through manway.

D Scraper blades are of advanced hinged type design, which insures positive scraping action on 98% of inside surface of mixer—without necessity of boring shell or bottom head.

E Constructed of any standard steel or special alloy to meet most exacting specifications.

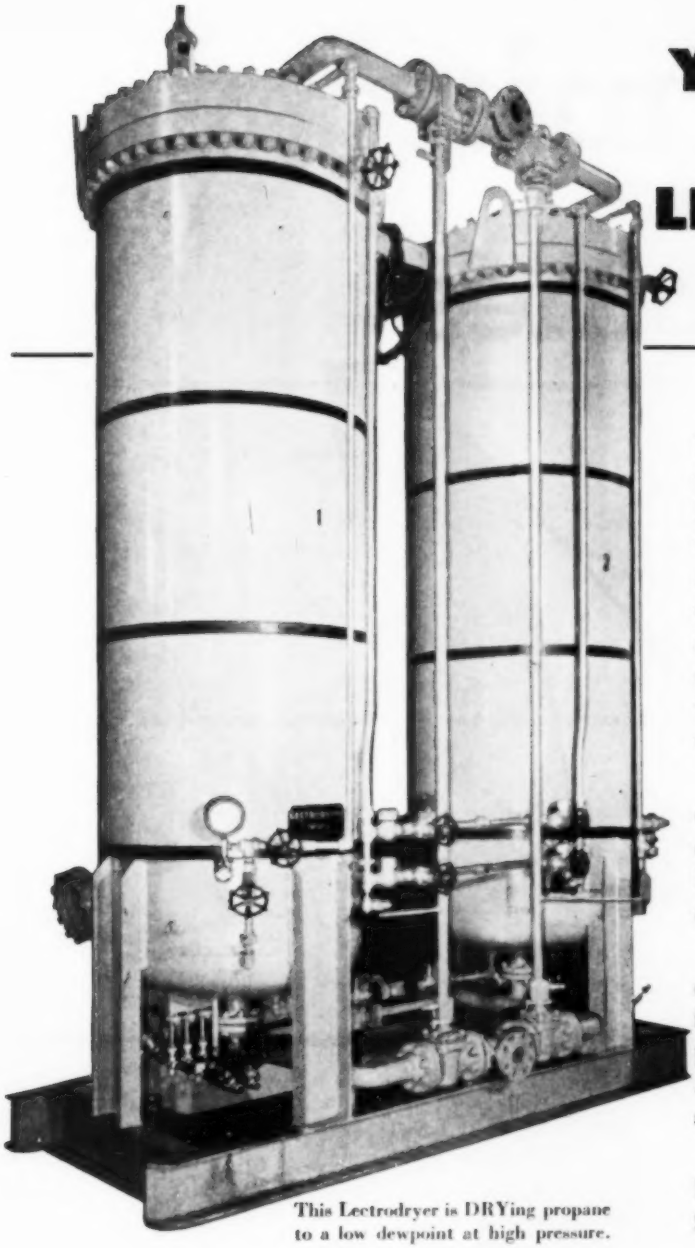
F Kettles are furnished with jacket or unjacketed for direct fire applications.

For speed, economy and dependability—specify the Struthers Wells Double Motion Mixing Vessels—for processing greases and other heavy viscous materials. Our extensive machine shops and fabricating facilities—combined with years of engineering experience in designing all types of agitating vessels, enable us to furnish mixing equipment for any material, to your most rigid specifications.

For intricately designed or standard mixing equipment—*think first of Struthers Wells.*

Struthers Wells CORPORATION

PROCESSING DIVISION • WARREN, PA.
PLANTS AT WARREN AND TITUSVILLE, PA.



This Lectrodryer is DRYing propane to a low dewpoint at high pressure.

You pay so little for LECTRODRYER'S experience

Lectrodryer engineers are veterans at this DRYing business. They started DRYing air, gases and organic liquids when a processor had to design, build and gamble on the effectiveness of his own drier. Today the knowledge our men have gained throughout the years, on jobs in every industry all over the world, is at your command without extra cost.

No need for you to have the bother, extra expense and delay which so often develop in building a new product. Lectrodryers are as standard as motors; a type and size for every service.

Let Lectrodryer advise you on a dryer when the job is still on the drawing board. You may save at several points by using standard equipment. And, when the Lectrodryer gets on stream, you know it's going to work.

For DRYing help, write Pittsburgh Lectrodryer Corporation, 307 32nd Street, Pittsburgh 30, Pennsylvania.

In England: Birlec, Limited, Tyburn Road, Erdington, Birmingham.
In France: Stein et Roubaix, 24 Rue Erlanger, Paris XVI.
In Belgium: S. A. Belge Stein et Roubaix, 320 Rue du Moulin, Bressoux-Liege.

LECTRODRYERS DRY WITH ACTIVATED ALUMINAS

LECTRODRYER

* REGISTERED TRADEMARK U.S. PAT. OFF.

Catforming combines these 4 advantages

The Atlantic Catalytic Reforming Process brings you:

1. high yield

The Atlantic Catforming Process was specially designed to produce high octanes at high yields. It properly balances all the many reactions necessary for the production of high octanes, assuring you of a high yield-octane relationship and maximum liquid recovery of high octane products from any feed stock.

2. low cost

Catforming units can be designed by *your own* contractor, thus providing important economies and greater simplicity. Commercial units of from 750 to 12,000 BPD charge capacity are now being built at investment costs of only $250 to $400 per barrel. In operation, no feed preparation, product finishing or costly regeneration facilities are needed.

3. stability

The catalyst in the Atlantic Catforming Process retains reforming activity for extensive periods, and at the same time has no loss in selectivity. Even under the varied conditions encountered in normal refining operations, catalyst life is from 35 to 100 barrels per pound.

4. ruggedness

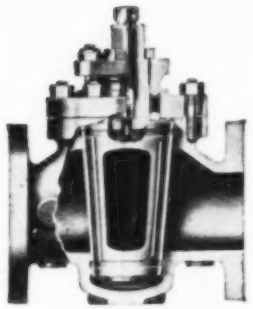
Activity and selectivity of the Catforming catalyst are virtually unaffected by water, sulphur compounds, and nitrogen compounds normally encountered in naphtha reforming. Atlantic's catalyst has *proved* its ability to resist physical and chemical change.

FOR COMPLETE DETAILS call or write The Atlantic Refining Company, Research and Development Dept., P. O. Box 8138, Philadelphia 1, Pa. (Telephone, Howard 5-2345.)

It's the catalyst that counts

ATLANTIC

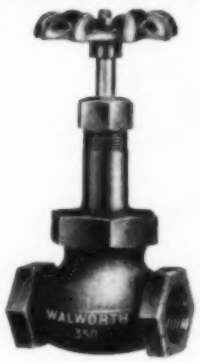
● VALVES
● PIPE FITTINGS



Walworth
Lubricated Plug Valve

Walworth
Steel Gate Valve

Walworth
Iron Body Gate Valve



Walworth
"500 Brinell" Bronze Globe Valve

Walworth
Iron Body Saddle Gate Valve

Walworth
Cast Steel Flanged Fittings

Walworth manufactures a *complete line* of valves and pipe fittings: all made to the highest standards of quality, both as to dimensional accuracy and metallurgical properties. In design, construction, and performance, Walworth products reflect more than a century of experience in the manufacture of quality valves and fittings.

Your Walworth distributor will give you full information on the *complete line* of Walworth steel, iron, and bronze, and special alloy valves and pipe fittings; also Walworth Lubricated Plug Valves, and Walseal® valves, fittings and flanges. Ask for this information today.

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Are you having Condenser-tube Failures?

Do you want to make your operations MORE PROFITABLE?

Let's offer this helpful suggestion: avail yourself of the specialized experience of Wolverine's staff of competent engineers. They are equipped to analyze your tube failures and make the recommendations as to the proper alloy that will best meet your particular requirement—resulting in longer tube-life and reduced operating costs.

Wolverine Tube Division produces plain condenser tube in copper and all popular copper alloys—Wolverine Trufin (the integral finned tube) in copper, copper base alloys, aluminum, bi-metal (aluminum fins with copper or copper alloy liners)—and Wolverine Electric-welded steel pressure tube.*

You'll be interested in getting a copy of our new Corrosion Chart showing various substances which produce corrosion action in metal. Sent free upon request.

Wolverine Trufin and the Wolverine Spun End Process available in Canada through the Unifin Tube Co., London, Ontario.

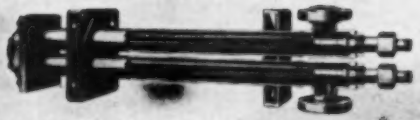
*REG. U. S. PAT. OFF.

WOLVERINE TUBE DIVISION
of CALUMET & HECLA, INC.
Manufacturers of Tubing Exclusively
1431 CENTRAL AVENUE • DETROIT 9, MICHIGAN
Plants in Detroit, Mich. & Decatur, Ala. *Sales offices in Principal Cities*

ESTABLISHED 1916

EXPORT DEPT., 13 E. 40th ST., NEW YORK 16, N. Y.

G-R
finned tube
HEAT TRANSFER APPARATUS



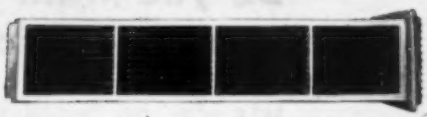
Twin G-Fin Section, used on a greater variety of heat transfer services than any other design of apparatus.

G-Fin Storage Tank Oil Heater, available in designs for installation partly within or entirely outside of tank.

G-Fin Heat Exchanger, for cooling large quantities of gases, or for cooling or heating viscous liquids.

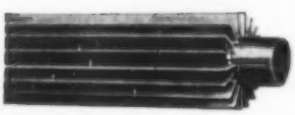
K-Fin Tar-Heated Reboiler, for separation of liquids which do not have close distillation curves.

K-Fin Atmospheric Section, used in the Fin-Fan Air-Cooled Exchanger, many hundreds of which are in use all over the world.

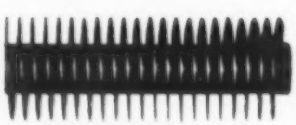


K-Fin Air and Gas Cooler and Heater, widely used to cool air or hydrogen from generator windings.

Headquarters for Finned Tube Units



G-Fin Element with longitudinal fins



K-Fin Element with helical fins

More than 30 years ago, G-R originated the first finned heat exchanger element that would withstand high temperatures and pressures.

G-R has, since then, developed many additional designs of finned elements and many different types of finned tube units, each for a specific range of services.

Today, the G-R line of finned-tube apparatus covers every heat transfer duty in the petro-chemical industries. These units include vapor condensers, heaters, coolers, and heat exchangers . . . for light, heavy, viscous and dirty liquids, vapors and gases . . . for small and large capacities at low and high temperatures and pressures.

The operating records of the many tens of thousands of installed G-R finned tube apparatus have proved the superior effectiveness, reliability, durability and economy of maintenance of these units. Whatever your heat transfer needs may be, be sure to ask G-R for recommendations.

THE GRISCOM-RUSSELL CO., MASSILLON, OHIO

GR 307

GRISCOM-RUSSELL

PIONEERS IN HEAT TRANSFER APPARATUS

Lower your costs by switching to Stainless Steel Valves

There are many installations in the Oil Refining Industry where ordinary steel valves seem adequate—for awhile. But later on sour crudes or other corrosive fluids take their toll. Excessive maintenance and replacement begins.

When you install (or replace with) Powell Stainless Steel Valves, their much longer life and lower maintenance will repay, many times over, the slight differential in the cost of these valves.

The Wm. Powell Co.
Cincinnati 22, Ohio

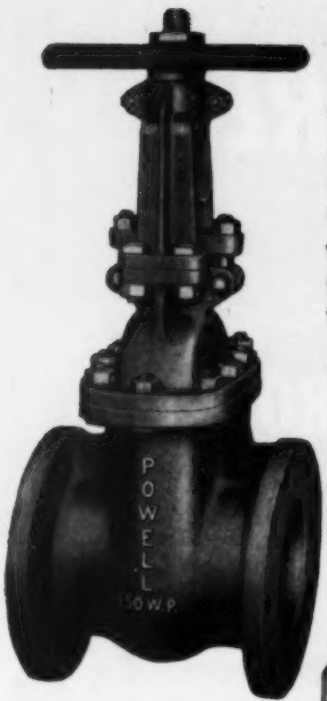
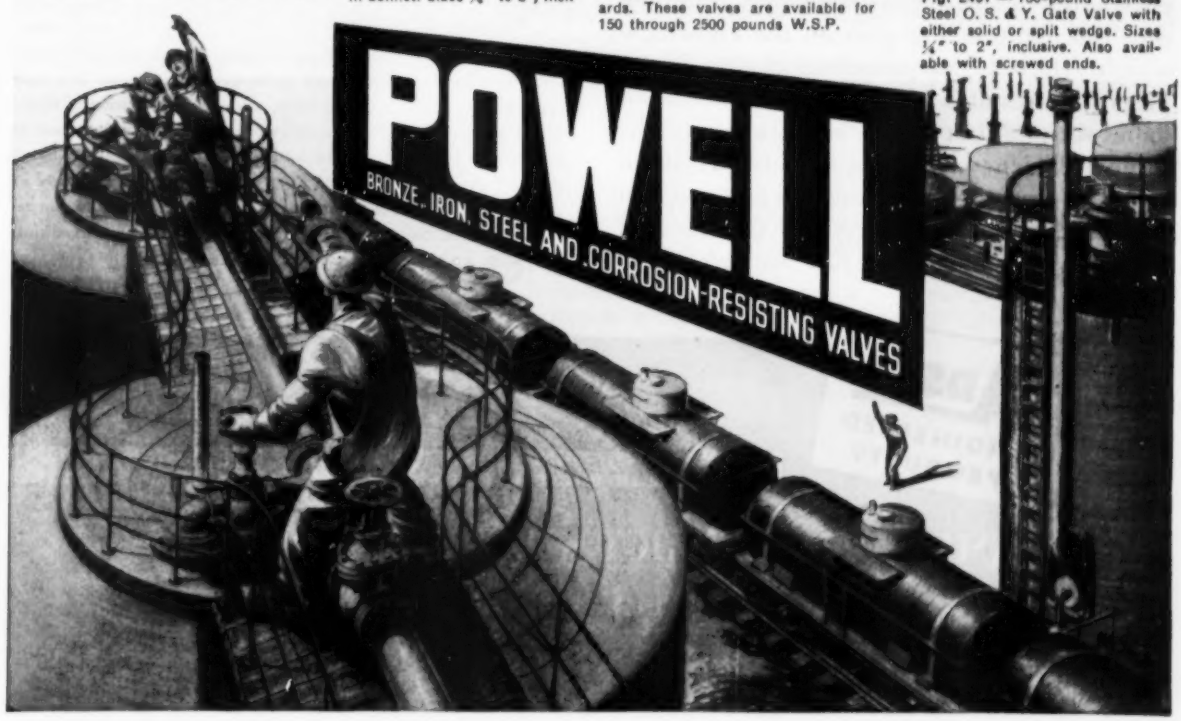


Fig. 2453-G — Large 150-pound Stainless Steel O. S. & Y. Gate Valve. Precision-fitted, accurately guided interchangeable solid or split wedge. Separable yoke arms in sizes 5" to 30", incl. Conforms to all the latest standards.

Fig. 1832—200-pound Stainless Steel Gate Valve with screwed-in bonnet. Sizes ¼" to 2", incl.

Fig. 3061 S. S. — 300-pound Stainless Steel Swing Check Valve. Made from a heavy steel valve pattern, it conforms to A.S.A. and A.P.I. Steel Valve Standards. These valves are available for 150 through 2500 pounds W.S.P.

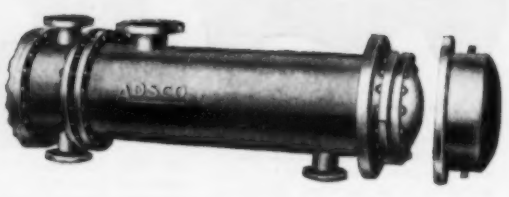
Fig. 2491 — 150-pound Stainless Steel O. S. & Y. Gate Valve with either solid or split wedge. Sizes ¼" to 2", inclusive. Also available with screwed ends.



ADSCO ENGINEERED

TO SOLVE ANY HEAT-EXCHANGER PROBLEM

Standard-design or tailor-made, ADSCO heat exchangers are engineered and manufactured to fit the exacting needs of ADSCO's industrial customers. Upon receiving a set of thermal conditions from a customer, ADSCO first applies its many years of experience to the design of the exchanger. And then into the manufacture goes all the know-how which ADSCO has acquired during its 75 years. The result is an exchanger which is not "almost right" but exactly right, a unit of the utmost efficiency... Investigate this specialized ADSCO service. You'll find it is low-cost, yet everywhere carries the ADSCO mark of quality which since 1877 has made ADSCO a leader.



A type of ADSCO heat exchanger widely used in industrial plants is the float-head, split-ring heat exchanger shown above. It is used for heating, cooling, or condensing, or for a combination of these. Shells can be of steel or a non-ferrous metal with either steel or non-ferrous tube sheets. Tubes of the removable tube bundle vary in size from ⅜" O. D. to 1¼" O. D. The pitch can be square or rectangular, depending on the fouling conditions and cleaning requirements. ADSCO heat exchangers are manufactured in conformity with ASME code for unfired pressure vessels.

ADSCO ENGINEERED PRODUCTS

Expansion Joints . . . Separators . . . Meters . . . Steam Traps . . . Heat Exchangers . . . Strainers

AMERICAN DISTRICT STEAM COMPANY, INC.

NORTH TONAWANDA, NEW YORK

Since 1877

CROUSE-HINDS

Hazardous areas in this plant are lighted by Crouse-Hinds EV Series Explosion-Proof and Raintight Lighting Fixtures

Explosion-Proof LIGHTING FIXTURES

. . . EXCEED the requirements for service in highly explosive atmospheres

To be safe for use in such locations, the fixture must operate at a temperature below the ignition temperature of the gas-air or vapor-air mixture. Also, the fixture must be so strong that it will resist internal explosions without damage and so tight that it will prevent the escape of flames or burning gases which might ignite the surrounding atmosphere.

Crouse-Hinds EV Series explosion-proof and raintight industrial lighting fixtures meet all of these requirements PLUS a wide margin of safety for extra protection.

Complete listings are in Crouse-Hinds Condulet Catalog.

Crouse-Hinds offers a complete line of explosion-proof and dust-tight lighting fixtures for use in hazardous locations where fluorescent lamps are desired.

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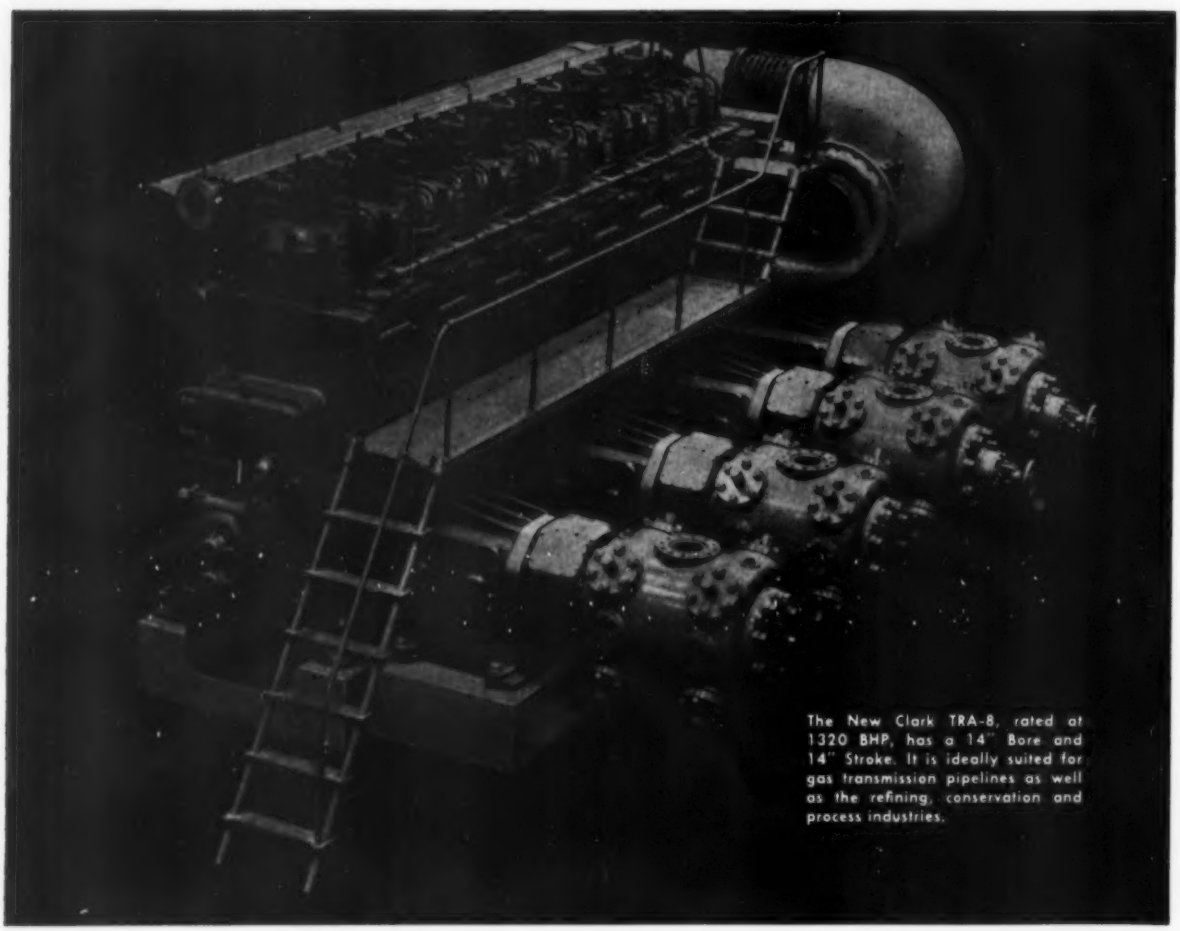
ITS HERE! a

The NEW Clark 2-Cycle



The New Clark TRA-8, rated at 1320 BHP, has a 14" Bore and 14" Stroke. It is ideally suited for gas transmission pipelines as well as the refining, conservation and process industries.

Clark Continues to Set the Pace in Compressor Progress

revolutionary compressor development!

Turbo-Charged "Right Angle"

It's here — after seven years of intensive development. Clark revolutionizes compressor design with the first 2-Cycle Turbo-Charged Gas Engine Driven Compressor . . . the TRA. Another Clark first! A precedent-shattering development that makes possible —

50% MORE POWER

Developing 1320 bhp, the TRA-8 delivers 50% more power than any comparable compressor, with *no* encroachment on overload carrying ability.

SHARPLY REDUCED FUEL CONSUMPTION

The TRA is conservatively rated *and guaranteed* to burn substantially less fuel than *any* gas engine driven compressor now built.

25% LESS COOLING WATER LOAD

(Including scavenging air intercooler load.) Vast amounts of waste heat are recovered from the exhaust gases by the Clark Turbo-Charger and are converted to useful work.

FLAT FUEL CONSUMPTION CURVE

Fuel consumption remains practically constant over a wide range of load conditions.

QUIET

Energy goes into power, rather than noise. Much quieter than a conventional gas engine driven compressor. No exhaust pulsations.

UNPRECEDENTED RUGGEDNESS

Tremendous stamina, unapproached by any other compressor design. Conservative BMEP rating.

COMPACT IN-LINE DESIGN

Very economical of floorspace, foundations and building requirements, yet highly accessible.

●

The Clark TLA, with 17" bore and 19" stroke, is also available when units of even greater horsepower than the TRA are required. For complete engineering details — the facts behind this revolutionary compressor development — see your nearest Clark representative and write for Bulletin 130.

CLARK BROS. CO. • OLEAN, N. Y.

DIVISION OF DRESSER OPERATIONS, INC.

SALES OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

CLARK compressors

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This photograph shows a WILFLEY Acid Pump application in a paper mill making gaseous chlorine for bleaching pulp. Because of their proven efficiency in handling acids, corrosives, hot liquids and other solutions, Wilfley Acid Pumps have earned a prominent place in modern operations of this great industry. **10-** to **2,000**-G.P.M. capacity; **15-** to **150**-ft. heads and higher. Wetted parts of all machinable alloys; plastic linings available. Individual engineering on every application. Write or wire for full details.

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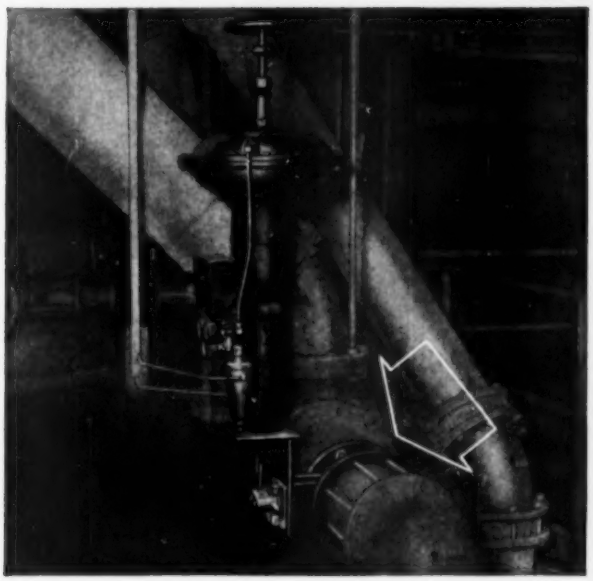
R-S valvEvents

• EXCERPTS FROM THE R-S BOOK OF EXPERIENCE •



No. 677-A—1500-pound welding-end steel valve for superheated steam service. A. S. M. E. standards with heavy duty handwheel control.

R-S VALVE ADVANTAGES
Under Automatic Control

1. Wide range of throttling from open to closed position. 30 to 1 is standard. Minimum torque required for positioning.
2. Any type of instrument or control actuator can be used depending on preference and conditions. In any application, the R-S Valve usually costs less to purchase, less to install and results in lower pumping costs due to simplicity of design.
3. R-S Valve design offers no pockets to capture sediment, no change of flow-direction to create turbulence. Freedom from turbulence reduces erosion and cavitation and therefore adds to the life of the valve.

R-S Valves are used for regulation, pressure reduction, liquid level control, flow control, shut-off and other functional applications.

No. 864—30-pound valve equipped with rubber seat, extended shaft, thrust bearing, floor stand and heavy duty handwheel control.

Consult your local R-S Valve Engineers, or write direct.

R-S PRODUCTS CORPORATION • 4600 Germantown Ave., Philadelphia 44, Pa.

An S. Morgan Smith Company Subsidiary

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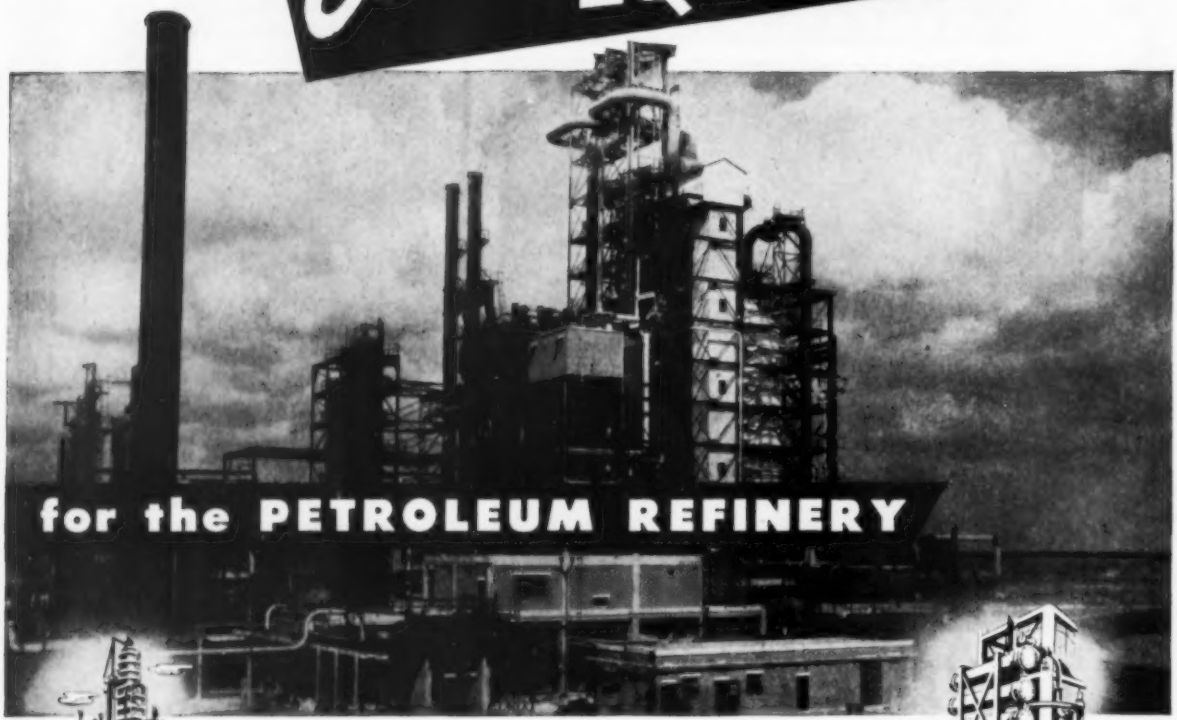
Essential EQUIPMENT



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STEAM BOILERS

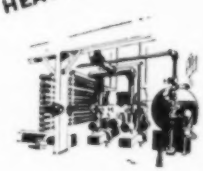
DROP FORGED STEEL VALVES AND FITTINGS

SELECT the process most suitable to your operating conditions and indicated future market requirements and then specify . . . Equipment by Vogt.

A wealth of research and engineering experience, combined with skilled operating personnel and exceptional manufacturing facilities, is incorporated in the wide variety of equipment we construct to all Codes.

Inquiries for detailed information on Vogt Products will receive prompt attention.

HEAT EXCHANGERS



REFRIGERATION MACHINERY

WAX PLANT EQUIPMENT

HENRY VOGT MACHINE CO., Inc.

LOUISVILLE 10, KENTUCKY

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CHEMICAL PROCESS NEWS

PUBLISHED BY CHEMICAL PROCESS DIVISION, THE M. W. KELLOGG COMPANY — JULY 1953

NOTES ON

UREA

As was announced recently, Kellogg is now in a position to make available a new, low-cost method of producing synthetic urea of exceptional purity from ammonia and carbon dioxide.

* * *

Known as the Montecatini Urea Process — after the well-known Italian firm which developed it — the new method reflects more than thirty years experience in the field of nitrogen chemistry.

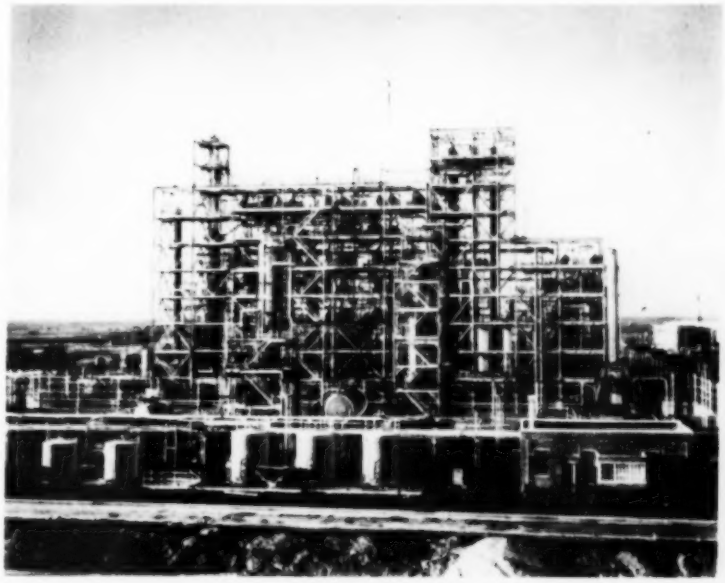
* * *

Many of the economic advantages of today's Montecatini synthetic urea process stem from metallurgical research over the past 20 years which has led to the elimination of costly silver- or lead-lined vessels. These have been replaced by less expensive stainless steel equipment. This has the added advantage of assuring an end-product free of metallic contaminants, making the urea entirely safe for sale to the growing cattle-feed market.

While metallurgical research has played the major role in improving the economics of the Montecatini synthesis operation, process improvements have also reduced initial investment and operating costs by relieving many of the more critical corrosive conditions.

* * *

These particular improvements were accomplished at a time when Montecatini was operating on a once-through basis for the production of urea. Most recent development in the process now being offered calls for the partial recycle of tail gas. With this practice 70% of the ammonia and 80% of the carbon dioxide are converted to urea. The remaining 30% of the ammonia may readily be converted to fertilizer.



Greatly Reduced Coking and Improved Yields in Kellogg's Unique Ethylene Process; New Pyrolysis Method Adaptable to Ethane

Commercial operating reports from an ethylene plant in England that Kellogg designed and erected continue to show remarkably low coke formation despite high conversion. It employs a unique pyrolysis step, a product of the Kellogg pilot plant laboratory.

Whereas conventional ethylene pyrolysis furnaces usually average only a few weeks on-stream before being shut down for coke removal, this plant showed only slight coke deposits when inspected after 12 months continuous operation. During this period it was operated with sufficient severity to convert 55 to 60 wt. % of the naphtha to C-4's and lighter gaseous products.

The special Kellogg-designed fractionation system which purifies the ethylene has also proved highly efficient. This is demonstrated by the fact that it produces 99.94% pure ethylene. The amount of impurities is actually 50% less than design. And this purity is obtained while recovering 95% of the total ethylene.

In addition to producing high quality products over extended periods, the process has been engineered to obtain maximum economy of the heat required for pyrolysis. From an operating cost standpoint, a special design in the quenching system, which follows the pyrolysis step, plus the use of low-level heat by the absorption refrigeration system, provide major savings by recovering most of the heat used in cracking.

Pilot Plant Studies Reveal Adaptability

Meanwhile continuing pilot plant studies are being carried out in the Kellogg labs on using various adaptations of this pyrolysis process to produce high purity ethylene from ethane, propane and other feed stocks. Test runs indicate that the Kellogg method will produce higher yields of ethylene and less coke than conventional processes.

(SEE REVERSE SIDE)

CONTINUED FROM PRECEDING PAGE

Capital Investment Lowered in Phthalic Anhydride Plants

Several design improvements which lower capital investment are being incorporated in new Fluid phthalic anhydride plants now underway for two major chemical companies abroad.

Most important is a re-design of the condensing system which not only reduces capital investment but also improves operating conditions. For example, it precludes any need for operators to come in direct contact with the phthalic or its fumes.

When completed the two new plants will produce about 50 million pounds of phthalic annually.

Meanwhile Kellogg's lab has developed a new feed-preparation step which permits the use of low-grade, sulfur-containing naphthalenes in the Fluid process. The step assures the processor of the higher yields possible with the fluidized catalyst system as well as its other advantages: lower initial cost... easier handling of catalyst . . . longer catalyst life . . . and increased safety through better control of heat.

New Iso-Octyl Alcohol Plant Takes Shape

Under construction by Kellogg, this new plant employs the Oxo process and is scheduled for completion in 1953. Photo was taken from the northeast corner of the site with rundown tanks and fractionator towers in the foreground. Also shown, on the concrete foundation, are alcohol, alcohol re-run, and aldehyde towers. The control room is at bottom right.

MOST RECENT PROGRESS PHOTOS OF GASOLINE-FROM-COAL SYNTHESIS PLANT

MORE THAN TWENTY MAJOR CHEMICAL PROCESSING STEPS . . . are involved in the gasoline-from-coal synthesis plant Kellogg has engineered and is currently erecting for South African Coal, Oil & Gas Corporation (SASOL) in South Africa.

While overall program is directed toward the production of fuels from coal, the processes involved also produce an assortment of oxygenated and other chemicals which are recovered in Kellogg-designed purification system. (Work under way in right photo.) Among the chemicals which will be produced as dictated by market conditions are ethanol, propanol, butanol, acetone, methyl ethyl ketone, benzol, toluol, phenol, ammonium sulfate, light and heavy creosotes, and several waxes and tars. Shown at left in above illustration is the synthol reactor in which the actual synthesis step takes place. The reactor is a development of Kellogg's pilot plant laboratories.

Typical Current Kellogg Chemical Plant Contracts

- ★ Phenol-from-cumene (2)
- ★ Iso-octyl-alcohol
- ★ Ethylene
- ★ Polyethylene
- ★ Ammonia
- ★ Phthalic Anhydride (2)
- ★ Glyceride Purification
- ★ Liquid Fuel and Chemicals Synthesis from Coal

For further information, technical data, etc., relating to chemical or petrochemical processing, write

CHEMICAL PROCESS DIVISION

THE M. W. KELLOGG COMPANY

225 Broadway, New York 7, N. Y.

Also Jersey City, Los Angeles, Tulsa, Houston, Toronto, London and Paris

KELLOGG — PULLMAN

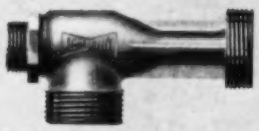
PENBERTHY *Jet Pumps*

(EJECTORS • EDUCTORS • EXHAUSTERS • SYPHONS)

Often the MOST ECONOMICAL and EFFICIENT WAY to Transfer and Mix Fluids

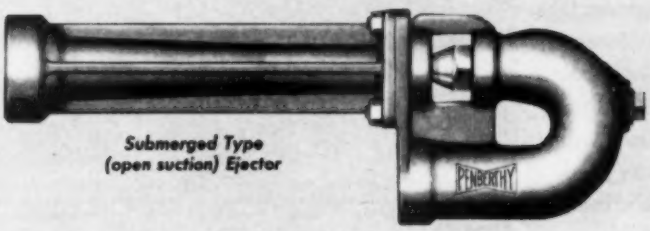
The jet pump is a simple device which uses steam, water or air under pressure to pump (or mix) fluids that can include solids in suspension. Jet pumps have no moving parts, need no lubrication, have no packing glands, are practically noiseless. They are low in initial cost and installation cost . . . compact in size and trouble-free. Penberthy offers a variety of jet pumps for a wide range of ordinary and unusual applications. They can be made from materials that withstand corrosion, contamination and high temperatures. Ask for new Bulletin 512.

Standard Ejector for Steam or Air Operation



Standard Hydraulic Ejector

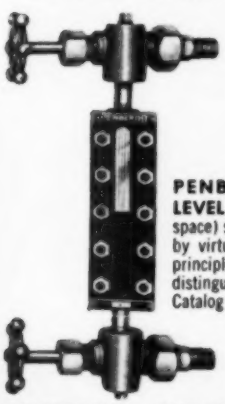
Stainless Steel Jet Pump for Handling Corrosive Chemicals



Submerged Type (open suction) Ejector

WRITE FOR *New* BULLETIN No. 512

OTHER PENBERTHY PRODUCTS



PENBERTHY TRANSPARENT LIQUID LEVEL GAGE—Used to observe color and density of liquids under high pressures and/or temperatures. Exceptionally sturdy construction—liquid chamber machined from solid block of metal. Ask for Catalog 35.

PENBERTHY REFLEX LIQUID LEVEL GAGE—Empty space (or steam space) shows white and liquid shows black by virtue of a simple, unvariable optical principle. Accurate reading as far as you can distinguish black and white. Write for Catalog 35.

PENBERTHY AUTOMATIC INJECTOR—Will supply feed water to boiler at minimum cost. Quickly, easily installed, reliable under most severe operating conditions. Ask for Bulletin 513.

4731

PENBERTHY INJECTOR COMPANY

DIVISION OF THE BUFFALO-ECLIPSE CORPORATION

Detroit 2, Michigan

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Established 1886

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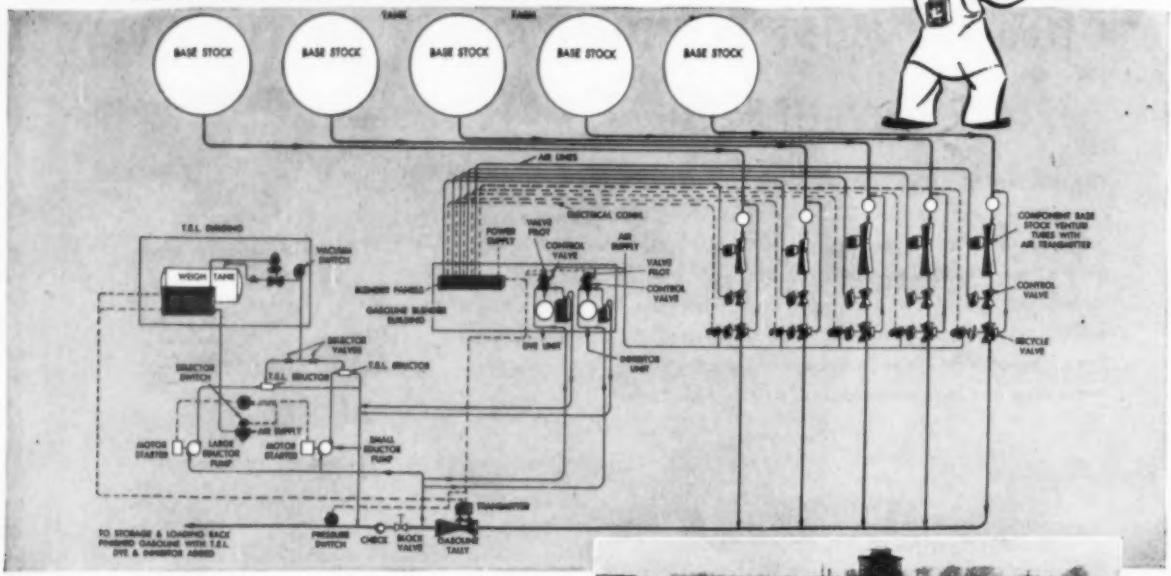
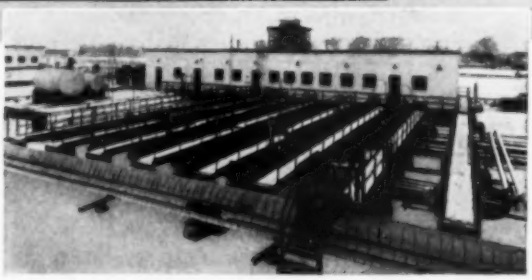
Canadian Plant—Windsor, Ontario

Are you still Batch Blending?

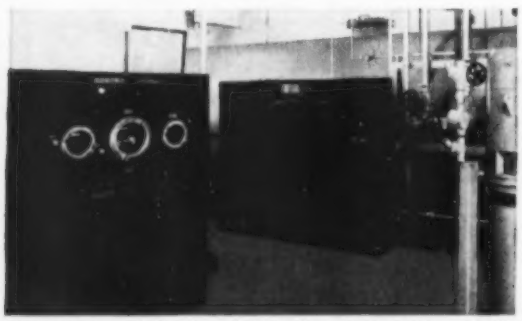
%PROPORTIONEERS% "ON-STREAM" BLENDING SYSTEM PROVIDES NEW SPEED, FLEXIBILITY AND ECONOMY IN THE DIRECT LOADING OF FINISHED GASOLINES



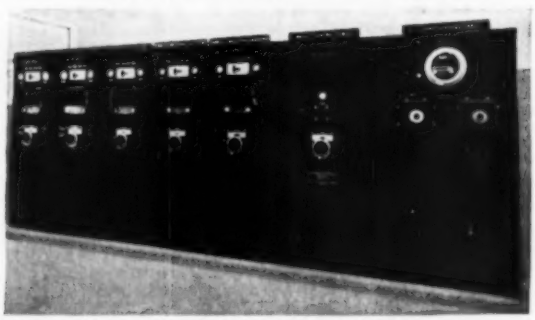
%PROPORTIONEERS% "on-stream" blending methods combine two or more liquid components in any proportion by weight or volume and formulations are maintained under all circumstances by automatic built-in "fail-safe" design features. Costly mixing tanks are eliminated, manpower and plant space saved, and internal transfer problems are greatly simplified. Ask for recommendations and descriptive literature.



New plant of Canadian Oil Refineries, Ltd. at Sarnia, Ontario, employs %Proportioneers% equipment to continuously blend five gasoline components, TEL, and dye, in producing its famous White Rose products at loading rates up to 2,880 barrels per hour. Photo shows Automatic Blend Manifold with Pump House and Control Room in background (TEL building in left hand corner).



%Proportioneers% Loss-in-weight Scale and Control Panel adds TEL to finished blend in proportion to flow rate.



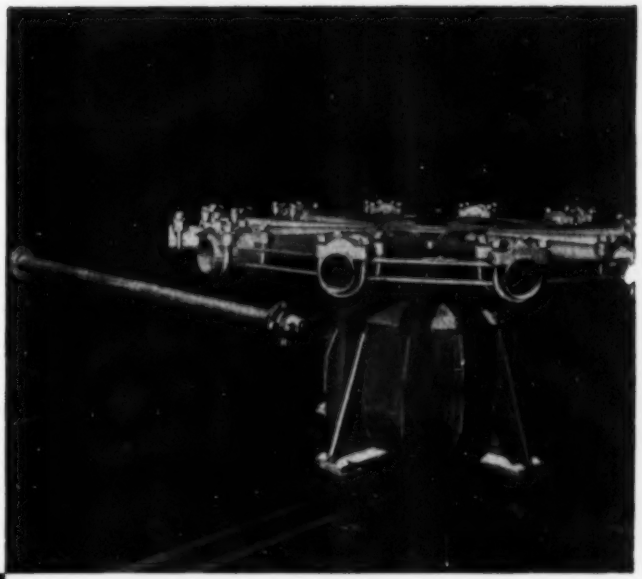
%Proportioneers% Gasoline Blender Control Panels with automatic batch cutoff panel at right.

%PROPORTIONEERS, INC.%

Write to %PROPORTIONEERS, INC.%, 412 Harris Ave., Providence 1, R. I.

Technical service representatives in principal cities of the United States, Canada, Mexico and other foreign countries.

MARLEY Mechanical Equipment is POWERED for PERFORMANCE



Driving the large fans of modern cooling towers is a rugged job . . . one that demands power transmission equipment designed with an extra measure of sturdiness. With its added strength it must also be precision built for long, smooth service. That's why Marley designs and manufactures every element of the mechanical equipment for Marley cooling towers. The result is specialized equipment for a specific service.

MARLEY GEAREDUCER*

An exclusive Marley design utilizing hardened alloy steel gears, tapered roller bearings and heavy, carefully machined shafts—all in an extra strong, well sealed, cast iron case. Lubrication to every point is constant and flow is maintained whether operation is forward or reverse.

MARLEY TWINFLEX* DRIVE SHAFT

This accurately balanced assembly is constructed of heavy steel tubing zinc-coated and sealed against internal corrosion by welded flanges. It transmits power to the cast steel yoke through pre-moulded neoprene inserts bonded to cadmium plated steel cores. They have excess load capacity that easily absorbs starting shock and transmits power smoothly.

MARLEY FAN HUB

This hub for largest fans is of all-steel construction. Hub spokes are seamless steel tube; center hub and clamps are steel castings. It is precision welded throughout for great strength. After fabrication, the hub is hot dip galvanized. The design provides quick adjustment for fan pitch and uses a retention pin for added safety.

Any Cooling Tower May Be Modernized with Marley Mechanical Equipment

The Marley Company

Kansas City, Missouri

MARLEY

NO BREAKS WITH PENFLEX ON TANK SETTLEMENT

PENFLEX FLEXIBILITY ALLOWS LINES TO WALK WITH TANK

Write for this helpful folder, "Flexineering" . . . your guide to flexible tubing

Heat . . . cold . . . tank settling . . . all made rigid pipe on oil storage tanks in a large New England bulk plant move, bend and break. Every break meant oil and gasoline lost . . . fire a constant threat.

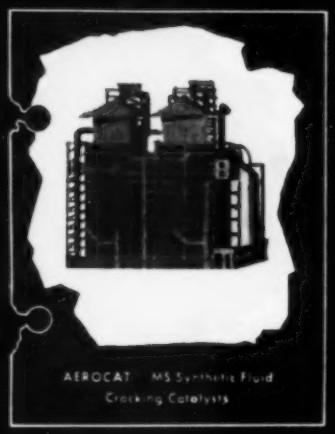
Then Penflex "Flexineering" solved the problem. Pipe breakage has been eliminated with a length of 12" I.D. four-wall interlocked, specially packed Penflex tubing . . . installed with tight-packed flanges. Now any amount of thermal expansion or tank settling can occur with no leaks, breaks or spillage. Penflex tubing is tight as a pipe . . . yet flexible under all conditions.

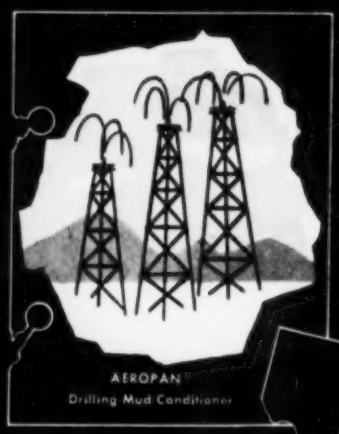
Let Penflex engineers help solve your tubing problems. Penflex manufactures a complete line of four-wall interlocked and seamless welded corrugated flexible tubing . . . metallic hose, tubing or couplings from 1/8" I.D. and up . . . automatic barrel fillers, accessories and fittings.

Pennsylvania Flexible Metallic Tubing Company, Inc., 7207 Powers Lane, Phila. 42, Pa.
Branch Sales Offices: **Boston • New York • Chicago • Houston • Cleveland • Los Angeles**

PENFLEX

HEART OF INDUSTRY'S LIFE LINES





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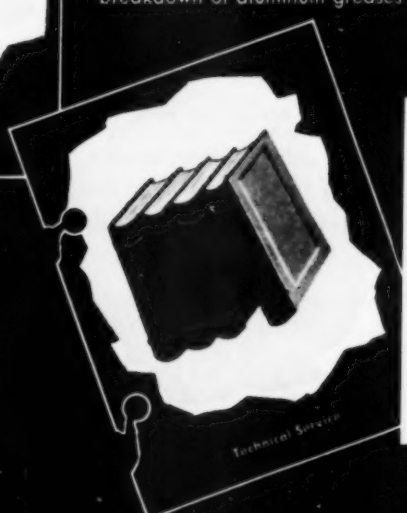
to meet your chemical requirements

An important part of Cyanamid's integrated service to the petroleum industry is its ability to meet the chemical requirements of the industry's every phase.

Cyanamid Chemicals range from drilling mud conditioners to specialty catalysts and lube oil additives. Each is the result of continuing basic research by Cyanamid's Refinery Chemicals Department — and of the knowledge gained in the field by Cyanamid's specialists.

Cyanamid Chemicals today are contributing to the improvement of many types of petroleum products.

One example: Cyanamid Gelling Agents for the lubricating grease manufacturer embody the latest advances in scientific research, among which is greatly improved gel stability obtained by replacement of a small part of the stearic acid with dimer acid. Standard ASTM and SOD tests also show improved yield and resistance to mechanical breakdown of aluminum greases produced with these new gelling agents.



AMERICAN *Cyanamid* COMPANY

REFINERY CHEMICALS DEPARTMENT, DIV. PR7
30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

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With Scovill men and methods on your team, you will get plenty of practical, helpful "signals" to long-life heat exchanger tube performance.

Scovill Phosphorized Admiralty Tube (Alloy 363), for example, is *made* differently... hot extruded from CONTINUOUS-CAST billets. As a result, it is *always* uniform in composition and temper; inhibitor content (phosphorus) is *always* at optimum percentage. Such tube shows superior resistance to corrosion and dezincification, especially where contaminated fresh, salt, or brackish waters are used in the circulation system.

Equally important, Scovill provides what many consider to be the most competent and comprehensive Heat Exchanger Tube Technical Service in the field. We make it our business to see that you get the right tube for your application and conditions... selected from the wide range of heat exchanger tube alloys we produce.

Inquiry and an outline of your needs are encouraged. Write on your business letterhead for our 40-page heat exchanger tube booklet. Scovill Manufacturing Company, 99 Mill Street, Waterbury 20, Conn.

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HEAT EXCHANGER TUBE ALLOYS

- PHOSPHORIZED ADMIRALTY
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- RED BRASS, 85%
- DEOXIDIZED COPPER
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- COPPER NICKEL, 10% & 20%
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- DUPLEX TUBE

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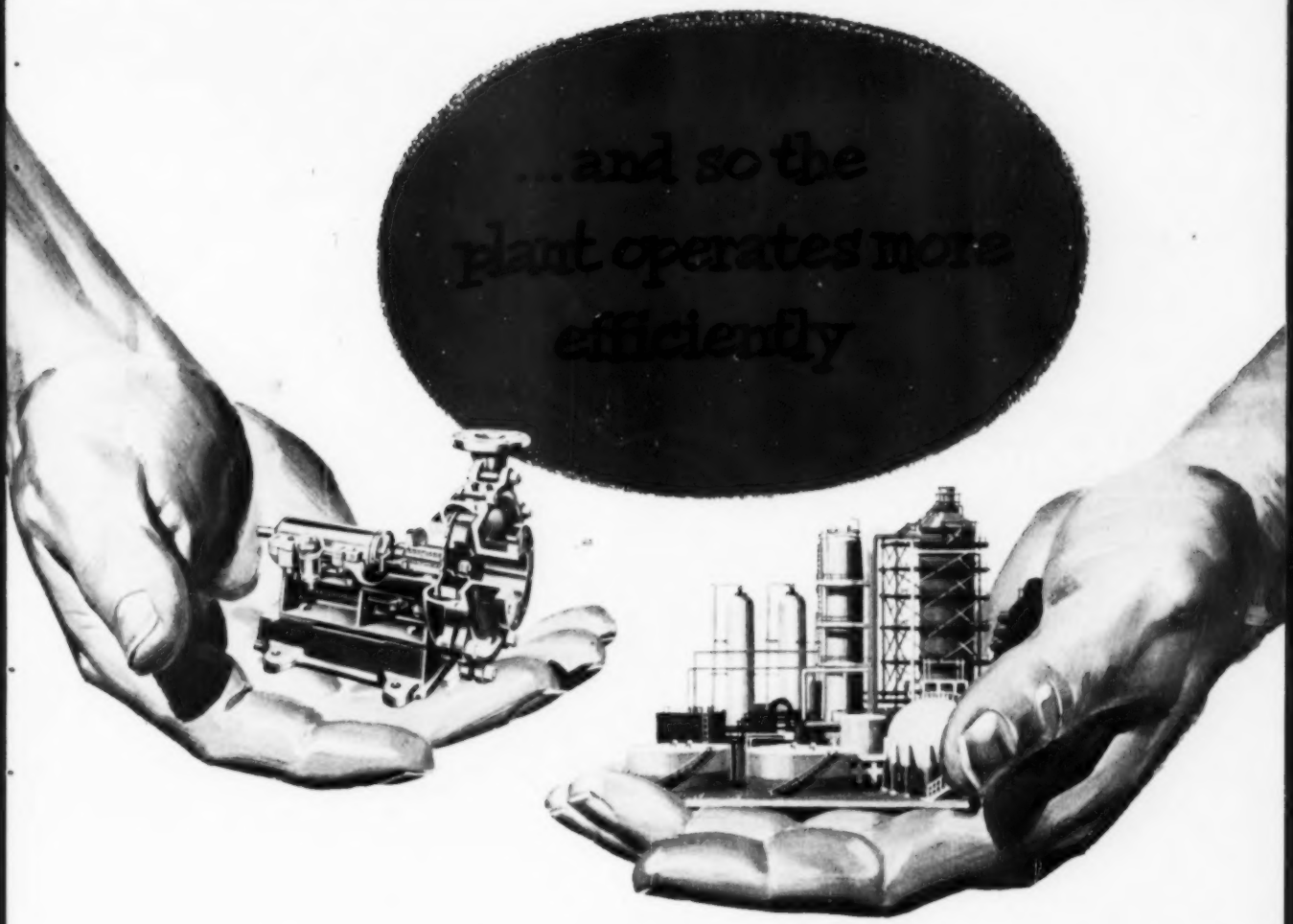

because MISSION *Centrifugal* Pumps Last Longer

The concentric casing design of Mission Centrifugal Pumps minimizes the excessive turbulence and cavitation normally caused by cut water in the conventional design which causes wear. The reduced turbulence affords smoother operation of the pump making the over-size heavy-duty bearing last longer under severe conditions and the rugged construction of Mission pedestal parts also affords longer life.

The special bearing housing can be replaced completely without disturbing pedestal alignment or casing, impeller clearance adjustment by external screw, high interchangeability of parts reduces replacement inventory, casing sizes ranging from 1" to 6" discharge, capacities up to 1800 gpm, heads up to 350 feet, speeds up to 3500 rpm. These and many other features found only in Mission Centrifugal Pumps all combine to give long life and easy maintenance.

Performance records prove that Mission Centrifugal Pumps keep your plant on stream with no expensive down time. Mission Centrifugal Pumps are now in service for major companies in the processing industries throughout the world.

We would like to quote on your requirements and show you how Mission Centrifugal Pumps can help your plant operate more efficiently. Write for Bulletin CP-452.

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Handled by representatives in all industrial areas . . . and by supply stores in every oil country.

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If you think your Workmen's Compensation Insurance costs are too high, why not do something about it? If you have a Safety Program, give it your wholehearted and enthusiastic support to insure its success. If you do not have a Safety Program, get one organized at once.

Remember you CAN do something about those on-the-job accidents — and remember, the lives of your employees are in your hand. Don't let a single one of them be killed or injured because of your neglect.

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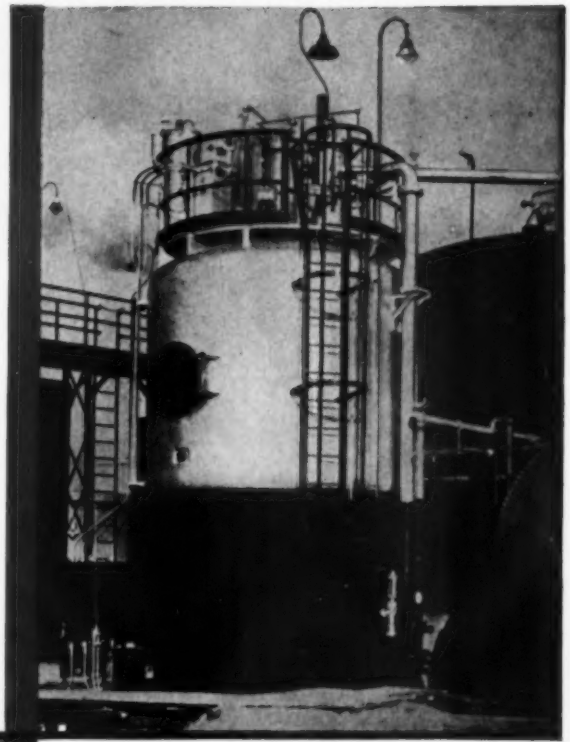
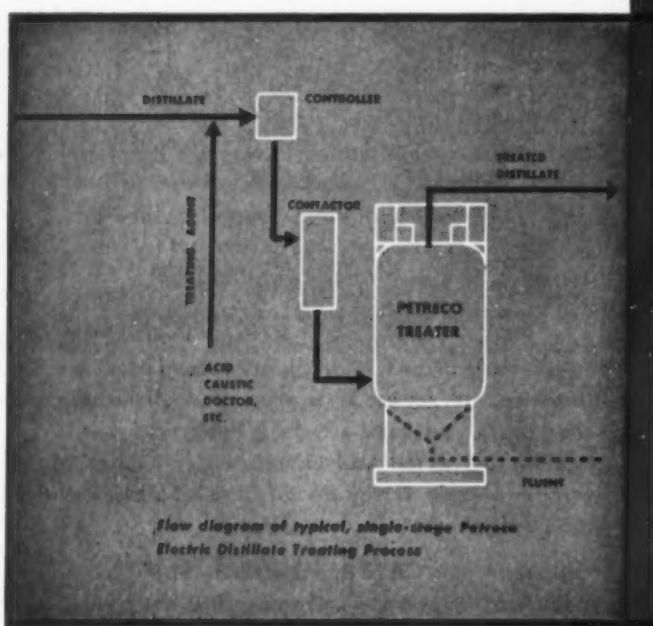
Be sure to get the facts on the NEW

PETRECO

ELECTRIC DISTILLATE TREATING PROCESS

The new Petreco Electric Process takes the guesswork out of distillate treating. It is applicable to acid, alkali or doctor treating of distillate stocks such as naphtha, gasoline, kerosine, cat-cracker charges, cat-cycle oils, diesel fuel and furnace oil.





Flow diagram of typical, single-stage Petreco Electric Distillate Treating Process

ADVANTAGES

COMPACT — requires minimum space, minimum equipment.

ECONOMICAL — uses less treating agent, gives higher product yield.

AUTOMATIC — injection, contacting and separation are automatically precision-controlled.

RELIABLE — the automatic, precision-control assures definite, predictable results.

EFFICIENT — treated distillate is relatively free of pepper-sludge, caustic, doctor solution.

POSITIVE — assures a quick break and complete separation. Amount of acid-sludge is reduced and is more suitable for re-use or recovery; emulsion in caustic effluent is eliminated; no blackstrap is formed in doctor treating.

NON-POLLUTING — the system is entirely closed. There is no chance for irritating fumes to escape.

COMPLETE — water washing is eliminated, except in some unusual cases.

EASILY MAINTAINED — the closed system, with no moving parts, stays clean; does not break down.

PETRECO

ELECTRIC PETROLEUM PROCESSING

CRUDE OILS: REMOVAL OF SALTS, SOLIDS, OTHER IMPURITIES; DEHYDRATING

DISTILLATES: ACID TREATING; CAUSTIC TREATING; DOCTOR TREATING

FUEL OILS: DESAPONIFICATION, ASH REMOVAL

For complete information, call or write

PETROLITE CORPORATION

PETRECO DIVISION

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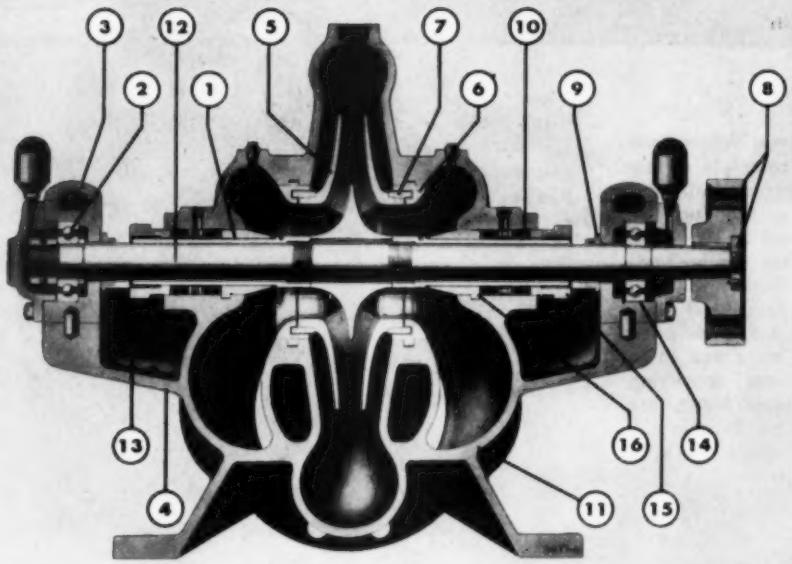
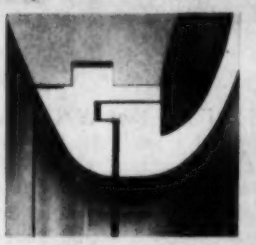
PD 53-1

DE LAVAL
SINGLE STAGE CENTRIFUGAL PUMPS

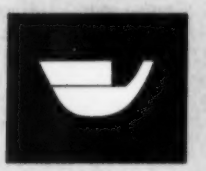
for dependable industrial service



Labyrinth wearing rings minimize leakage...maintain high efficiencies



Labyrinth rings used in these De Laval pumps retard flow of water through labyrinth passage.



Flat rings showing relatively unimpeded flow of water.

(1) **Shaft Sleeves** are screwed on, to abut the impeller and make a water-tight joint. Sleeve expands freely and independently of shaft when temperatures change. There is no tendency to buckle.

(2) **Thrust Bearing** locates rotor axially.

(3) **Bearing Caps** easily removable for maintenance.

(4) **Bearing Brackets** scraped to lining bars for perfect alignment.

(5) **Impeller** hydraulically balanced, finished on all surfaces.

(6) **Labyrinth Wearing Rings** held accurately in machined grooves in both case and cover.

(7) **Impeller Wearing Rings** threaded on impeller, opposite to rotation.

(8) **Flexible Coupling** ground on all exposed surfaces and statically balanced, complete coupling supplied, pump half mounted on taper so that it can be easily removed. Check nut locks coupling on taper.

(9) **Deflector** keeps water out of bearing.

(10) **Stuffing Boxes** extra deep; lantern rings for water sealing.

(11) **Pump Case** horizontally split; machined to limit gages.

(12) **Steel Shaft** ground to limit gages.

(13) **Drip Boxes** large; provided with drain openings.

(14) **Radial Bearing** free to move axially, thus avoiding temperature strains.

(15) **Glands** split horizontally.

(16) **Protecting Bushings** renewable.

You can count on the performance of the De Laval Single Stage Centrifugal Pumps because they are precision-made to high manufacturing standards and incorporate the many quality design features shown in the cross-section.

They operate at high or low speeds, at high or low heads...with maximum efficiency.

For example, De Laval G, I and K Single Stage Double Suction Pumps have a capacity range of 175 gpm to 6,000 gpm, and heads to 300 feet. They are available in sizes ranging from 4" suction and 3" discharge to 14" suction and 12" discharge. Write for Bulletin 1002.

DeLaval also furnishes larger centrifugals for capacities up to 70,000 gpm. Bulletin 83-29R sent on request.

DE LAVAL *Centrifugal Pumps*

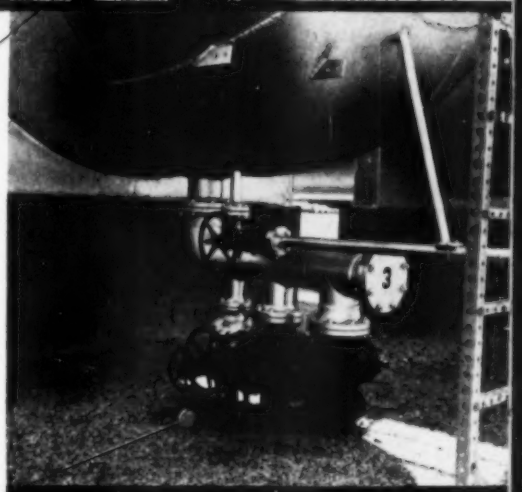
DE LAVAL STEAM TURBINE COMPANY

011 Nottingham Way, Trenton 2, New Jersey

DL 198

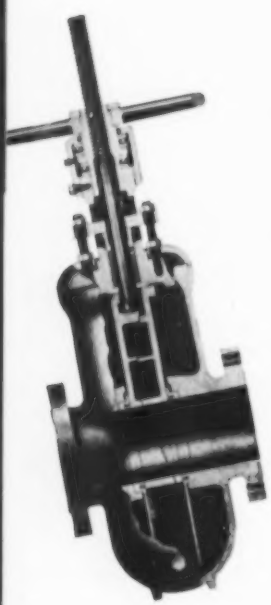
W-K-M PROCESS VALVES FOR GASOLINE PLANT SERVICE

When you figure that W-K-M Process Valves have metal-to-metal seals to provide complete safety under any conditions, that they permit full pipe-diameter flow without turbulence, that positive opening and closing are guaranteed by W-K-M's exclusive Leverlock design, that they can be completely overhauled with very little trouble while on the line, that they are available in any trim for any process service—high pressure hot or low pressure cold—it is no wonder that more and more gasoline plants and refineries are specifying W-K-M for the key jobs—and some plants use them all the way through. Write for Bulletin 698 for the complete data about these valves or ask for a W-K-M sales engineer to call.



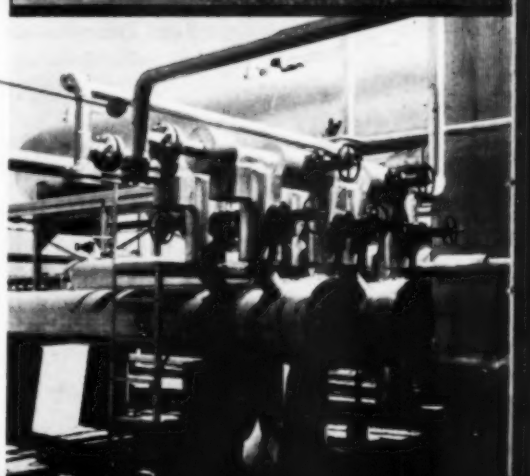
These valves and those shown below are in a gasoline plant in West Texas. Reading from left to right in above photo, the valves are in service on loading pumps handling butane, at 125 psi ga., 85° F; gasoline, 75 psi ga., 85° F; propane, 225 psi ga., 85° F.

W-K-M Valves on butane stock tank at 125 psi, 80° F. Four valves are used on each tank and there are ten tanks.



At left is cutaway section of the W-K-M Process Valve. Shown below is drawing of the exclusive W-K-M Leverlock mechanism which guarantees positive opening and closing under all conditions.

These valves provide reflux to propane fractionator. They handle propane at 275 psi ga., 108° F.



These jacketed valves handle unstabilized gasoline at 550 psi ga., 260° F. in deethanizer feed exchanger.

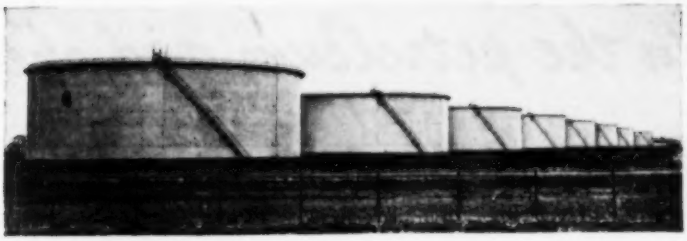
W-K-M Valves

W-K-M COMPANY

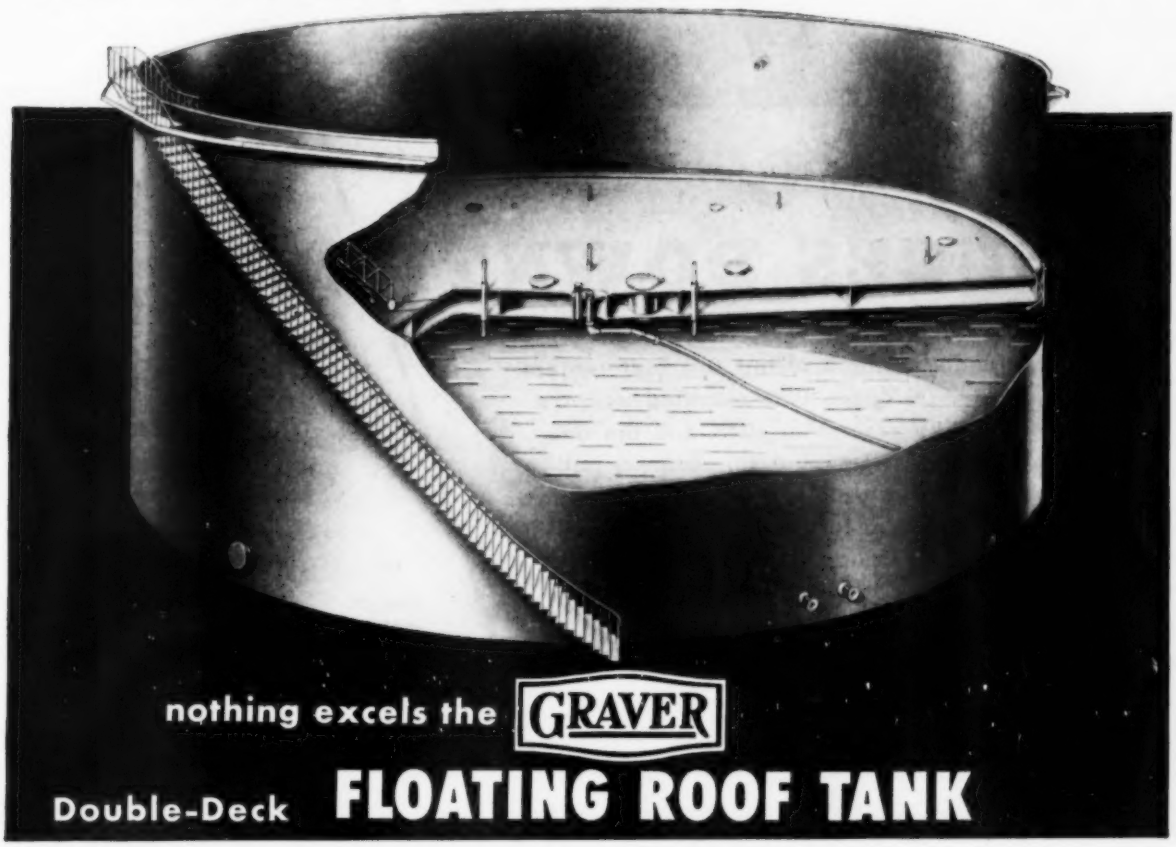
P. O. BOX 2117 HOUSTON 1, TEXAS

2330 E. 8th St., Los Angeles, Calif.

Export Office: 30 Rockefeller Plaza, New York, N. Y.



where THROUGHPUT IS HIGH



Where filling and emptying are daily operations, the Graver Double-Deck Floating Roof tank is an essential investment. The double-deck roof floats directly on the liquid, preventing the formation of gasoline vapors, negating standing losses and minimizing filling losses. It is especially applicable to product storage areas at refineries, at product pipe line terminals and at barge-supplied terminals.

It is also suitable for storage of sour crude where the danger of corrosion is ever present. Because the roof is everywhere in contact with the crude, the chance for the interaction of vapors and air is reduced and corrosion is minimized. For the ultimate in conservation tankage, specify the Graver Double-Deck. For further information, write for detailed brochure.

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GRAVER
CONSERVATION TANKS

in the petroleum and chemical industries

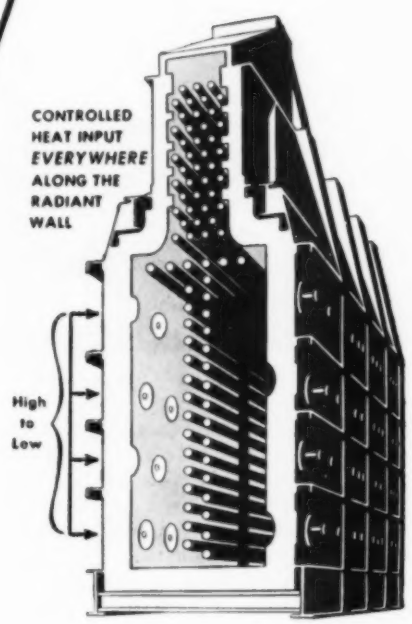
i f p*

REDUCES DOWNTIME

In any processing where cracking temperatures are approached, shorter residence time resulting from the use of higher average absorption rates, and the uniform application of heat combine to minimize coil coking. Selas **i f p*** has proved that process heaters can operate continuously for prolonged periods under these severe conditions without shutdowns for repairs or cleaning.

Built around the Selas Gradiation Heater, with its uniform application of gas-fired radiant heat along and around each tube, the *Improved Fluid Processing* methods are in use for fluid outlet temperatures as high as 1800°F.

Selas Bulletin S-6.2 describes methods, equipment and other savings. Write for it today.



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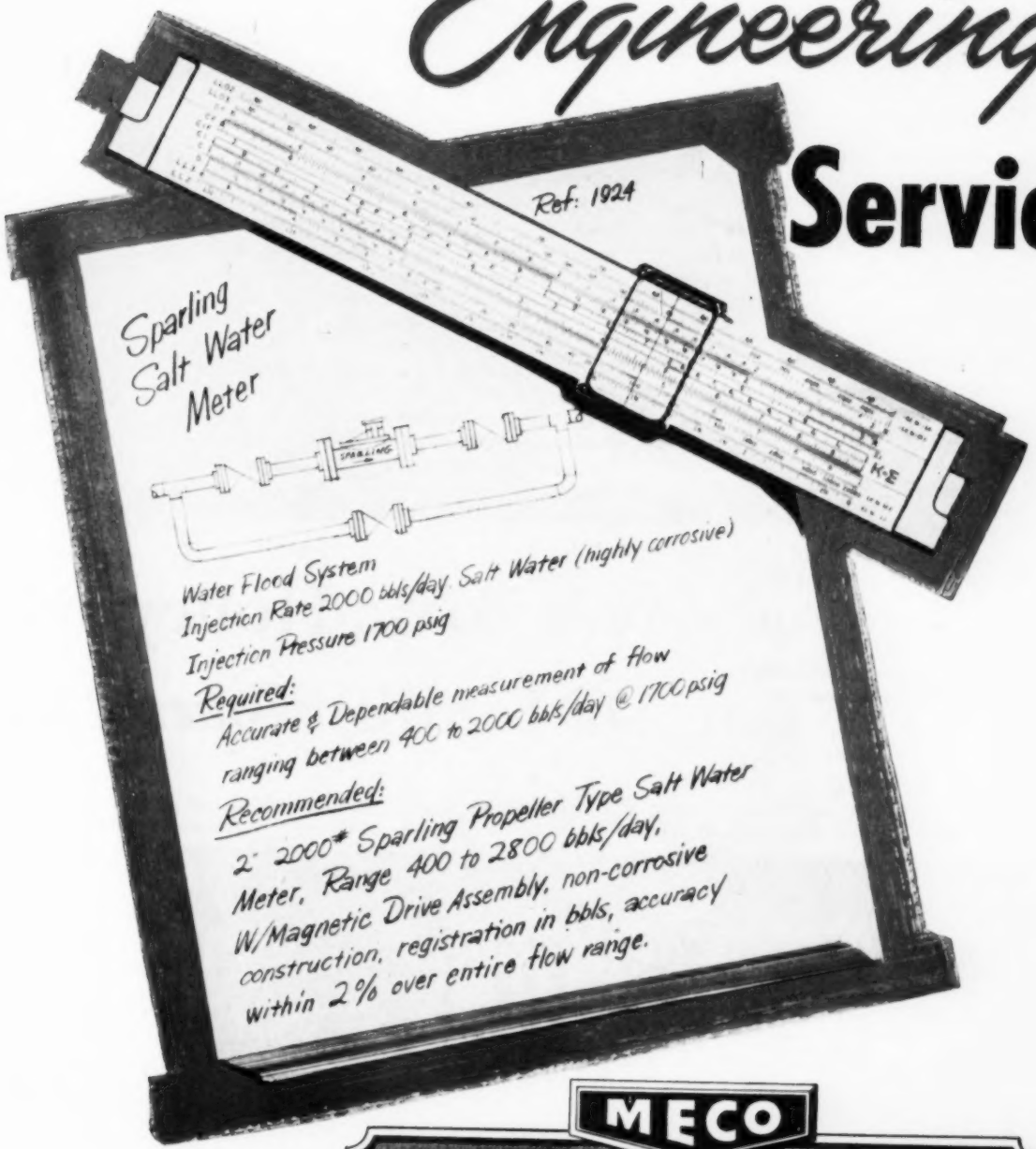

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MAINTENANCE *Engineering* CORPORATION

P. O. BOX 2637 — 5711 CLINTON DRIVE — HOUSTON, TEXAS

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The well-established trend to centralized graphic instrumentation has brought with it many specific advantages to the operation of complex, modern processing units. And to realize most fully the potential advantages of improved efficiency, simpler supervision and better coordination, many leading companies have turned to Honeywell graphic control.

Among the engineering, construction and producing organizations which use Honeywell panels are some of the best-known names in their fields. The ever growing list includes:

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Shell Oil Co.
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Standard Oil Co. of New Jersey
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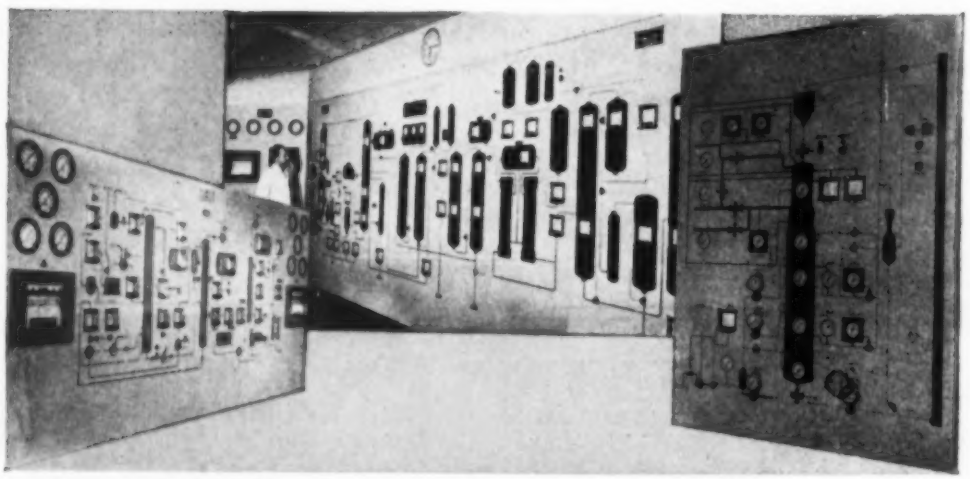
Reasons for acceptance

Behind this industry-wide acceptance stand several definite reasons. First is system engineering . . . by graphic panel specialists who translate process requirements into an integrated, harmonious design. Second is instrumentation . . . including a full line of *Tel-O-Set* miniature indicators, recorders and controllers, and *ElectroniK* instruments for supplementary recording, which enable Honeywell to satisfy the requirements of every phase of process control. And third is workmanship . . . skilled assembly in a manufacturing department devoted exclusively to this work.

Honeywell *operation*



FUNCTIONAL DESIGN *for maximum efficiency is the keynote of Honeywell graphic instrumentation. These typical panels show a few of the varied types which have been built for varied process applications.*

FUNCTION-DESIGNED CONTROL *for feed preparation unit, TCC unit and gas concentration unit is centralized on this Honeywell graphic panel . . . supplemented by ElectroniK instruments on the console desk and on the board at the extreme left.*

graphic control *simplifies of* new Phillips TCC unit

PHILLIPS PETROLEUM'S new unit at Okmulgee, Oklahoma is an outstanding example of skilled application of modern design. It is the first air-lift thermofor catalytic cracker to be equipped with full graphic control . . . which Honeywell designed and built for this exacting application.

On a board 41 feet long and 7 feet high is concentrated complete control instrumentation for guiding the operation of the 8,000-barrel-per-day TCC unit, fired preheater, flash drum, vacuum still, and gas concentration unit. The variety of instrumentation illustrates the versatility of Honeywell graphic control. Included are *Tel-O-Set* Indicators and Recorders for critical flows, differential pressures, liquid levels and temperatures throughout the unit. Installed directly in the process diagram, these miniature instruments give operators accurate, conveniently-read facts on each variable.

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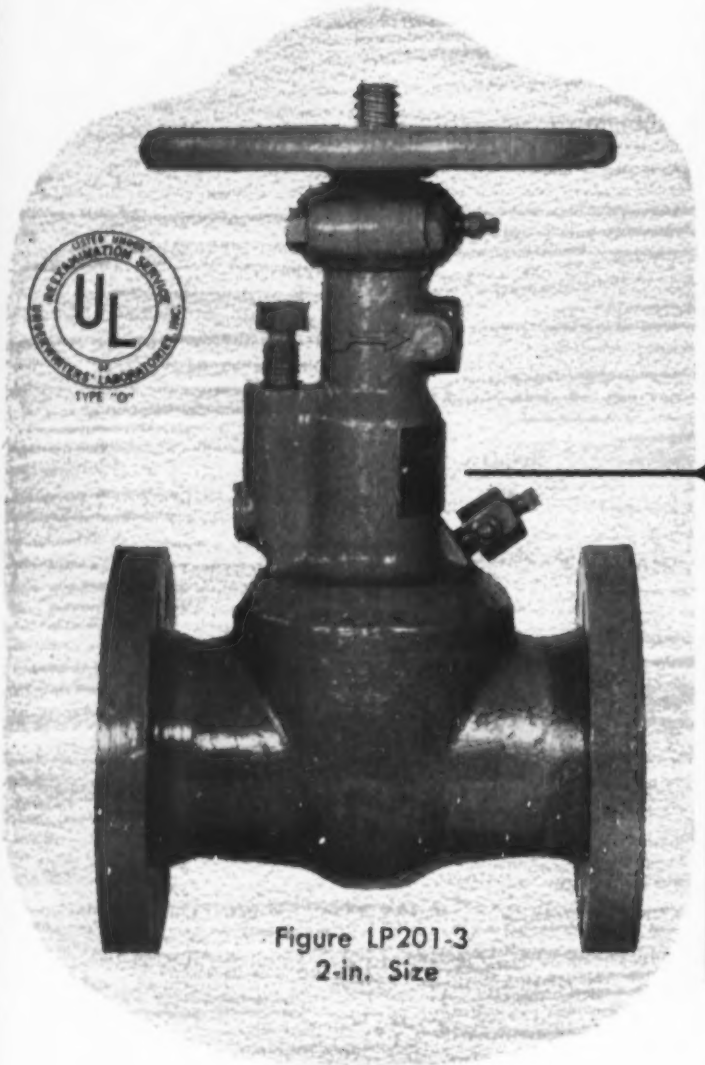

Figure LP201-3
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The **Mail** Box

A Great Author Is Grateful

Dear Sir:

I am truly grateful for the reception granted this series ("Thermal Insulation for Industrial Requirements") by so many interested parties. From this response I believe that this series will provide needed guidance for many from whom we will never hear, in addition to those who have been kind enough to express themselves.

A total of 322 individual requests have been received from United States, Canada, Great Britain, Netherlands and Australia.

As to the stimulation indicated by the response, many compliments have been received. This, of course, is a wonderful means of tickling our vanity, but is not conducive to reconstruction of our thinking. I have been hoping that someone would take issue with certain statements in order that I might get a more representative reaction. Perhaps this will develop when I am privileged to meet some of them face to face.

Ray Thomas, Staff Engineer
Carbide and Carbon
Chemicals Company
South Charleston 3, W. Va.

Editor's Note: *In excess of 1000 of the reprints of this 10-part series (48 pages total) have been sold. We have only 445 copies remaining. The price is $1.00 each. Please address your request to the Reprint Editor and please remit with order.*

Calling the Shot

Dear Sir:

Coincidental with the receipt of the April Issue of PETROLEUM REFINER, which contained the article on our prepared drill plan of a fire on C-12 stabilizer reboiler No. 2 cracking unit, we had a fire on the C-12 stabilizer reboiler—No. 2 cracking unit. Damage was slight, but calling the shot was somewhat disturbing.

We appreciate the publicity given to our emergency organization. Working with Al Reese in preparation of this material was a pleasure.

Pan American Refining Corp.,
H. B. Williams, Director,
Safety and Fire Protection
Texas City, Texas.

Your observations and views on timely topics of interest to those in the processing industry are invited by the editors.

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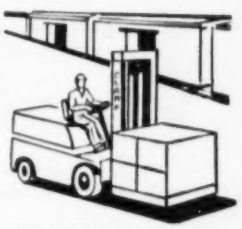

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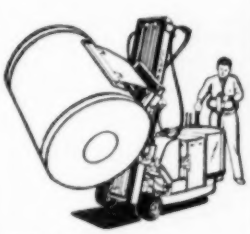

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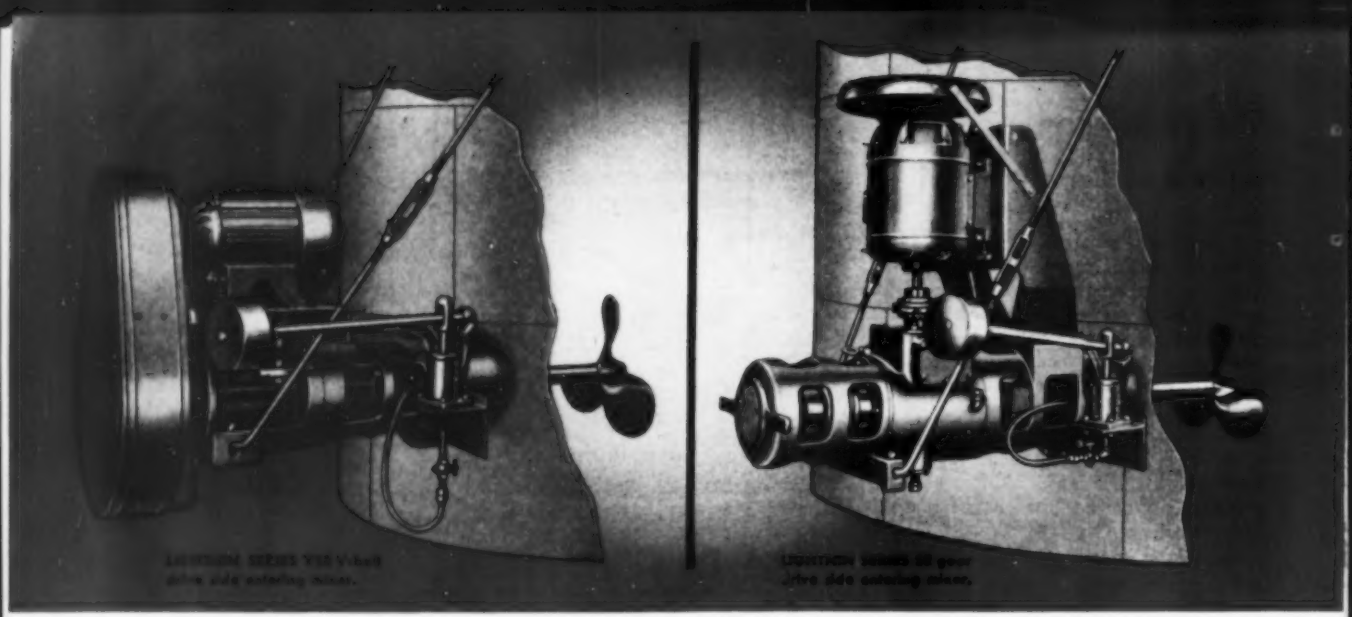

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The bigger the tank, the more economical it is to choose mixers closely matched to your needs.

You want just enough power to give you rapid, thorough tank turnover—but no wasted HP.

That's why each of the LIGHTNIN Mixers shown above is supplied in *nine* sizes, from 1 to 25 HP.

Your operating conditions may call for any of *four* standard LIGHTNIN stuffing boxes, or either of two standard mechanical shaft seals. In any case, the type you need is available and has been proved in use.

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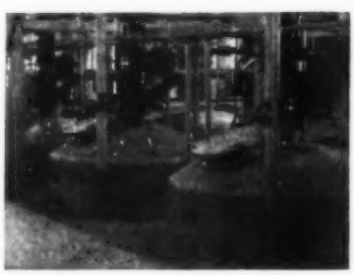
EASIEST REPACKING EVER . . . with either type, tank shutoff is actuated by turning these easy-to-get-at handles, for repacking with full head of liquid in tank.



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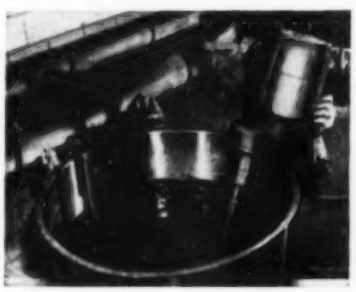

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The **Look Box** for July

Opportunity for Better Position

HIGHER U. S. crude price postings made in June provide opportunity for the industry to improve its economic situation, but care must be exercised to prevent overproduction from endangering that position.

The increase was badly needed by crude producers to help offset the inflated cost of finding and developing of oil reserves, but it came at a time when ample supplies did not seem to point to higher postings. Whether this necessary hike can prove permanent depends on immediate future levels of producing, importing, and refining operations.

This year, supply has outstripped demand. During the first five months, U. S. production of crude and natural gas liquids increased 6.2 percent over the 1952 level, and crude imports have been 24.3 percent higher. On the other hand, indicated demand for oils has risen only 5.9 percent over last year's rate.

The result of this apparent imbalance is the buildup of stocks. Crude inventories as of June 20 amounted to 278½ million barrels, more than 6½ million greater than at the year's outset. This accumulation of crude occurred despite near-record refinery operations.

Refining activity has been especially high this month, and has resulted in increased gasoline and distillate fuel production. Consequently, gasoline stocks have not been dropped as rapidly as is normal for the season and distillate stocks are growing faster than would be normally expected. If this continues, it is possible that the industry would enter the winter season with too much gasoline and fuel oil in its tanks.

On vs. Off The Job Safety

MANAGEMENT is becoming increasingly aware that the problem of personnel safety cannot be answered by making the job as safe as possible.

The company whose employe is injured off the job loses as much productivity—and is sometimes just as liable financially—as if the mishap occurred on the job, and there is a multitude of figures to demonstrate that off-job accidents happen with much greater frequency.

E. I. Du Pont found that more of its workers were injured off the job in January than were hurt on the job during the whole of 1952. In all Du Pont plants 144 were hurt away from work during January, whereas lost-time accidents for all of 1952 at work came to only 86. This indicates that, due principally to auto accidents, Du Pont's workers are from 10 to 14 times safer on the job than off.

At first glance these figures seem to contradict the long-held theory that a man who is safety conscious on the job will be safety conscious off the job, but another look at the figures weakens this conclusion. Even with this high accident frequency, Du Pont's employes were safer off the job than the average for the industry, and the average for the industry was better than for the public at large.

It is possible that the answer to round-the-clock well-being of people—when it is found—will entail entirely separate approaches to the problem of on-job safety vs. off-job safety.

Mixed Blessing For Industry

THE RAPIDLY increasing and widespread use of oil burners for home heating is proving to be a mixed blessing to the oil business. Uncertain production of coal tempted many home-owners to switch to oil for heating purposes. This quick switchover in public opinion was a resounding victory for oil over coal and opened a tremendous new market. But the worm in the apple has again raised his persistent head.

First was the severe winter of 1948 when a great number of oil furnaces had been installed and the oil industry couldn't meet the demand for heating oil. There was a great undercurrent seething of resentment which many oil company executives felt would result in federal regulation of the industry. To forestall such calamitous legislation, shoulders were put to the wheel and engineers prodded to expand production of heating oil immediately. Their efforts were highly successful and during the ensuing three years, everyone had plenty of heating oil.

But a second and frightening bugaboo has reared its head. Now the oil industry finds itself geared to a highly seasonal economy. Refineries must run wide-open (and often uneconomically) to meet heating oil requirements in the winter

Get these 3 big advantages

with new DuPont Fuel Oil Additive No. 2

1 **RETARDS RESIDUE FORMATION**—The stabilizing properties of Du Pont Fuel Oil Additive No. 2 are effective in reducing the rate of insoluble residue formation in distillate fuel oils.

2 **REDUCES PARTICLE SIZE**—When insoluble residues are formed, Fuel Oil Additive No. 2 acts as a dispersant to reduce the particle size of these residues. As a result of the combined dispersant and stabilizing properties, clogging of filters and nozzles can be practically eliminated through the use of this new additive.

3 **REDUCES RUST**—In storage tests, drums containing unstabilized fuel oil for periods up to 7½ months showed considerable rusting on the interior above the liquid level line. In drums containing the same oil stabilized with Fuel Oil Additive No. 2 during equal storage periods, this rusting was greatly reduced.

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IN CANADA: Canadian Industries Limited—Toronto, Ont.—Montreal, Que.—Calgary, Alta.

and then idle part of their equipment during the summer. A recent forecast by PAD indicates a drop in demand of 937,000 barrels daily for all oil products east of California. This is roughly 13 percent of the total refining capacity, and is due to drop off in heating oil demand.

Two possible solutions suggest themselves. First, process heating oil to more saleable products. Insofar as economically possible, that is now being done. Perhaps more research dollars should go into this field. Second, increase heating oil storage capacity at both the consumer and producer, thereby leveling out summer-winter production differences. Last year was a banner period for tank manufacturers selling to the producer. But the consumers aren't convinced and a hard-hitting and convincing public relations program is in order by refiners.

The two limits to the problem are catastrophic —produce too little and face government regulation, produce too much and lose your shirt. As in the case of many other equally serious problems that have faced it, the oil industry will find the answers. Petroleum is Progressive!

No Doubt About Rubber's Stand

WHATEVER DOUBT holds up the government in disposing of synthetic rubber plants is certainly not present in the minds of rubber company executives. Putting the case of the industry to the House Armed Services Committee, John L. Collyer, president of The B. F. Goodrich Company, said that "Congress should recognize that government ownership and operation of these plants means the socialization of the man-made rubber producing industry in the United States and the abandonment of competition among privately-owned companies which has made possible our country's great economic progress."

He stated further that "a bill now before your committee (the Shaffer bill) provides a reasonable and practical procedure and program for achieving, in the public interest, a progressive, privately-owned competitive synthetic rubber industry.

"It is our firm conviction that competition in the production and sale of all types of man-made rubbers will be in the interest of our present and future national security and in the long-range interest of our people to an extent which would never be possible under continued government ownership and operation of the production facilities."

For an engineer's eye view of the price the government should set on its rubber facilities, take a look at "The Selling Price of Synthetic Rubber Plants" on page 113 of this issue.

Petrochemical Editor—

DON S. RAWLINGS, JR., chemical engineering graduate of the University of Texas, has joined the PETROLEUM REFINER editorial staff to head up the Petrochemicals Department. Don is well-fitted to direct the REFINER's ever-increasing coverage of this important field. Since graduation in 1948 he has served as an engineer with a large southwestern petrochemical installation, the Neches Butane Products Company at Port Neches, Texas.

Rawlings

In the performance of his engineering duties at Neches, Don established a considerable reputation for his work in conventional and extractive distillation and dehydrogenation. Moving up rapidly through the ranks, Don held successively the titles of junior engineer, assistant process engineer, and process engineer. His numerous and highly varied assignments gave him first hand working knowledge and experience with process design, economic evaluations and operations.

According to the PETROLEUM REFINER's Editorial Director Dr. John McKetta, the addition of Rawlings will make possible even greater coverage of the petrochemicals field, in which the REFINER has long held the unchallenged leadership. Many of the REFINER's long range petrochemical plans are still labeled "confidential," but it certainly is no secret that petrochemical operators throughout the country can expect to see a lot of Don Rawlings in the next few months as he widens his circle of friends. His first assignment will be the planning of the Petrochemical Special Issue which is scheduled for November and is another REFINER first in the technical publishing field.

Publisher Ray L. Dudley had this to say: "The quality of PETROLEUM REFINER is a tradition that has been established through 35 years of service to subscribers throughout the world. Rawlings' personality and wealth of valuable experience suit him admirably for his part in the maintenance of this tradition. I know our many friends will join us in welcoming Don to the staff."

The new Administration is deserving of patience and cooperation from everyone, business men in particular. If on the contrary the latter, with a long-sought business type of administration in office, place their own selfish interests ahead of the country's they can look forward to little help from this or future administrations and will deserve less.

GEORGE V. HOLTON
Chairman of the Board,
Socony-Vacuum Oil Company, Inc.

LAGONDA

delivers the goods -fast!

TUBES SWEPT CLEAR of the toughest coke with the irresistable speed of a bulldozer through brush. Through tube after tube, without let-down, the self-feeding cutter head smashes the coke and shoves it out, backed by the powerful drive of the famous Lagonda 1100 Series motor with its ball thrust bearings front and rear, and its exclusive front end lubrication. Here's a combination that is both enduring and fast.

Fast, too, in getting to the job. Let a customer tell what he thinks of Lagonda deliveries: "This is a note of appreciation for the very fine service you rendered us on our recent order. It was received yesterday, well ahead of schedule. Thanks a lot."

When you need tube cleaning, you want *speed.* Call your local Elliott-Lagonda representative, or Elliott Company, Springfield, Ohio.

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LAGONDA DIVISION, SPRINGFIELD, OHIO

HERE'S VALUABLE TUBE CLEANING DATA.

Bulletin Y-34 is crammed with facts on cutting down time in cleaning still tubes. On request.

Y3-6

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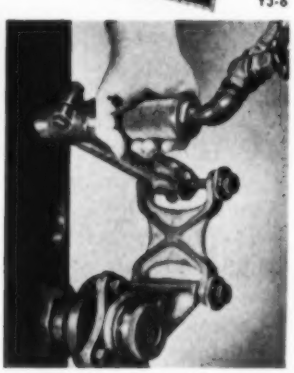
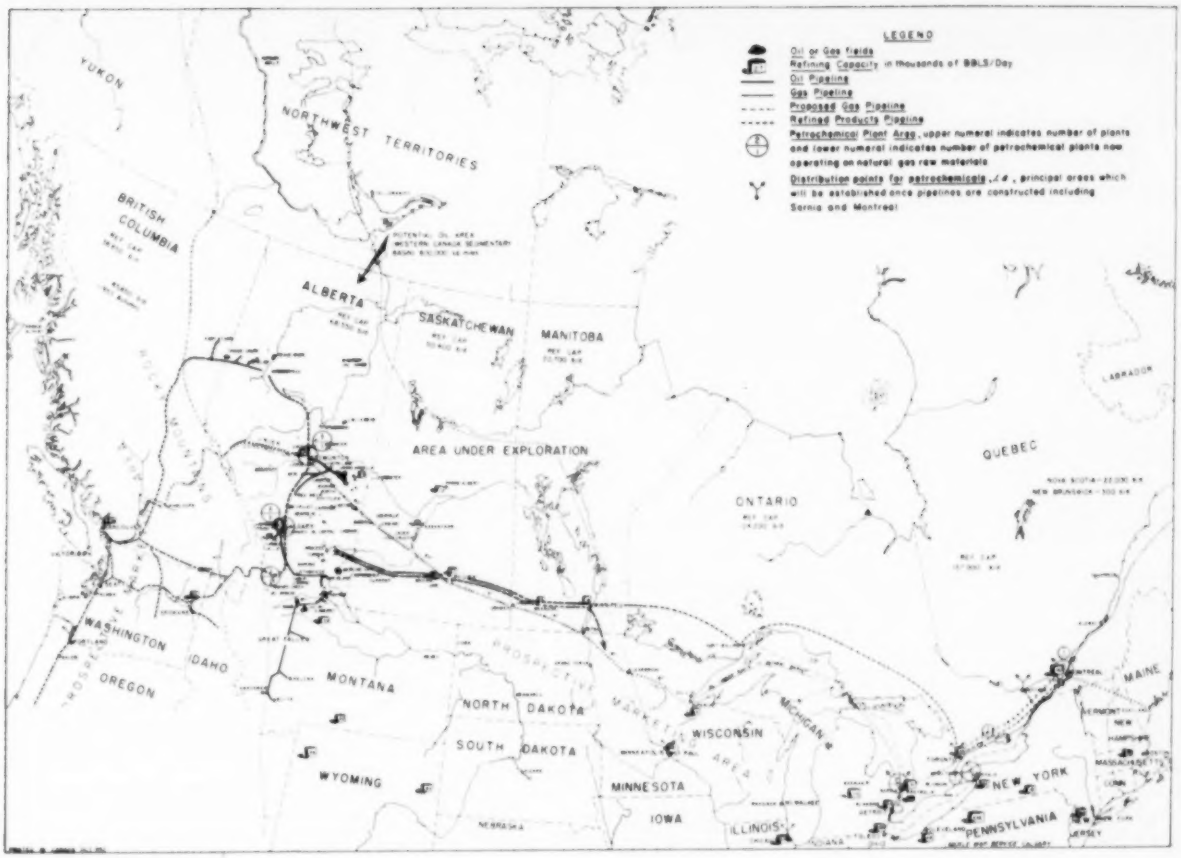
AUTOMATIC SIGHT FEED LUBRICATOR for pressure service. When pressure is on, lubrication starts. When pressure is shut off, lubrication stops. Simple and positive.

FOOT-OPERATED THROTTLE VALVE enables operator to handle tube cleaner with both hands, controlling pressure with his foot, like an auto accelerator.

CATALYST CLEANER. Removes spent catalyst from tubes, without permitting its escape. Also good in removing fly ash from the tubes of air preheaters.



HANDHOLE SEAT GRINDER. A precision tool for grinding handhole seats flat. Can save its cost on one job. Driven by air motor (electric motor optional).



Where is Canada Going in Petrochemicals?

These petrochemicals from natural gas show strong market potential:

- Ammonia
- Ethane-Ethylene Products
- Acetylene

Eugene F. Gibbons,
Designers for Industry, Inc.
Cleveland, Ohio

ALBERTA CAN BE called the petrochemical capital of Canada. Though this province is relatively distant from large consuming markets, with the large and growing reserves of natural gas found there, it seems likely that market difficulties will be overcome as gas transmission lines are constructed. Sufficient petrochemical markets are developing or are expected to develop as a result of natural gas discoveries in Alberta. The Petroleum and Natural Gas Conservation Board, operating under the jurisdiction of the Alberta Legislature, estimates Alberta's gas reserves at 6.8 trillion cubic feet of which 6.5 trillion cubic feet are required for the province's future requirements. This estimate is well below several independent appraisals which place the reserves at around 9 trillion cubic feet.

To overcome the distant marketing problems, a $260 to $270 million natural gas pipeline, connecting Alberta and Quebec (including Toronto, southern Ontario, Ottawa and Montreal) is expected to be under construction by summer, 1953. Westcoast Transmission Company is seeking a U. S. license to pipe natural gas from the Peace River field in northern British Columbia and Alberta to Washington and Oregon, via Vancouver, B. C. A proposed line in the Great Lakes region would offer another market

THE PICTURE as far as petrochemicals-from-natural-gas is concerned, shapes up something like this:
Eastern markets—excellent
Midwest—favorable
West—limited

outlet for Canadian natural gas. The line proposed by Western Pipe Line would swing south through the U. S., then north to Ontario at Sarnia. However, the Canadian government prefers that the line extend from Alberta to Winnipeg and then to U. S. markets around St. Paul, Minnesota. This would insure a "Canada-first" policy.

Therefore, the picture, as far as petrochemicals-from-natural gas is concerned, shapes up something like this: eastern markets—excellent; midwest—favorable; west—limited. Most of Canada's markets for petroleum products are already established in the east, and it seems likely that the petrochemical market will follow the patterns set by its petroleum brothers. Sarnia is considered to be the refining center of Canada, thus petroleum products' markets are already established in the Great Lakes region. The west is the big question mark at present. Certainly it offers proximity for a market of Alberta natural gas and petrochemicals, but location apparently is not the governing factor where marketing is concerned.

Marketing Significance to Alberta

Table 1 lists 15 types of petrochemicals which can be made from natural gas, or liquid hydrocarbon raw materials. However, this table lists the market potential to Alberta of petrochemicals which are made only from natural gas. Therefore, the reader is cautioned that where a compound listed in the table is classified as a poor market risk, the view is based only on the fact that the product is not suitable for production from natural gas. For instance, carbon blacks are listed as poor market risks, considering the inefficient yields from natural gas as the raw material. Carbon blacks do have a good market in Canada, but their principle raw material is *liquid* oil hydrocarbons.

As seen from Table 1, there are three major petrochemical products which show a strong potential market for Alberta and Canada—synthetic ammonia, acetylene, and ethane-ethylene products.

SYNTHETIC AMMONIA: Natural gas has become increasingly popular as a source of hydrogen for synthetic ammonia. In the post-war period the fertilizer industry has taken up the slack created by the need for ammonia derivatives in explosives, and the market has remained strong. The synthetic ammonia plant in Calgary, built by the Canadian government during the war and now owned by Consolidated Mining and Smelting Company, was the first industrial plant in Alberta to use natural gas as a basic raw material. Should a demand develop for urea, either as a fertilizer, as an animal nutrient, or in making urea-formaldehyde plastics, this could absorb a large production of ammonia. Urea synthesis would also utilize large quantities of the carbon dioxide now being produced as a by-product of the ammonia process.

Canada presently bases her synthetic rubber production on refinery gases; however, as needs increase, it may very well be that alternative sources of C_4 hydrocarbons will have to be found.

ACETYLENE: The processes for producing acetylene from natural gas (Schoch, Sachsse, and Wulff) are comparatively new, but if they develop as well as early results indicate it is likely that even for the small production in Alberta these hydrocarbon processes will eventually replace the older carbide process, because of intrinsic economies. Large scale production of acetylene would have to be based on its value as an organic building block. Prospects of such development in Alberta are excellent.

ETHANE-ETHYLENE PRODUCTS: Ethylene, as has been reported many times, is the basic building block for a host of other chemicals, including ethyl alcohol, ethylene oxide, ethylene cyanohydrin, polyethylene, ethylene glycol, ethanolamine, vinyl chloride, tetraethyl lead, and styrene. Ethylene production is a good index of the status of the synthetic organic industry. The petrochemical industry located in eastern Canada derives ethylene from refinery gases; a petrochemical industry in western Canada would undoubtedly use natural gas as the basic raw material.

Some of the products derived from ethylene that might have an immediate market in Canada are polythylene, ethanolamine and refrigerants. Markets for some of its other products will develop with the general industrial growth of petrochemicals.

With increasing quantities of ethane available from gas processing plants, there may be an increased usage of ethane in partial oxidation and substitution type reactions. However, in many cases, the alternative path of a preliminary dehydrogenation to ethylene followed by an addition reaction may prove to be more practical.

TABLE 1
Market Outlook of Alberta's Petrochemicals-from-Natural Gas

Strong Market Potential	Favorable Market Potential	Poor Market Potential
Synthetic Ammonia	Formaldehyde[1]	Carbon Blacks[4]
Ethane-Ethylene Products	Hydrogen Cyanide	Synthetic Fuels[4]
Acetylene	Butane-Butylenes-Butadine[2]	Nitroparaffins
	Oxygenated Organic Compounds	Helium
	Sulfur[3]	Carbon
		Carbon Dioxide
		Nitrogen

[1] Conversion from synthetic methanol.
[2] No immediate market. Slightly more long-range than others in this category.
[3] On a limited scale.
[4] Liquid hydrocarbon raw materials more suitable.

Promising Outlook

The following five petrochemical classifications have a favorable market outlook:

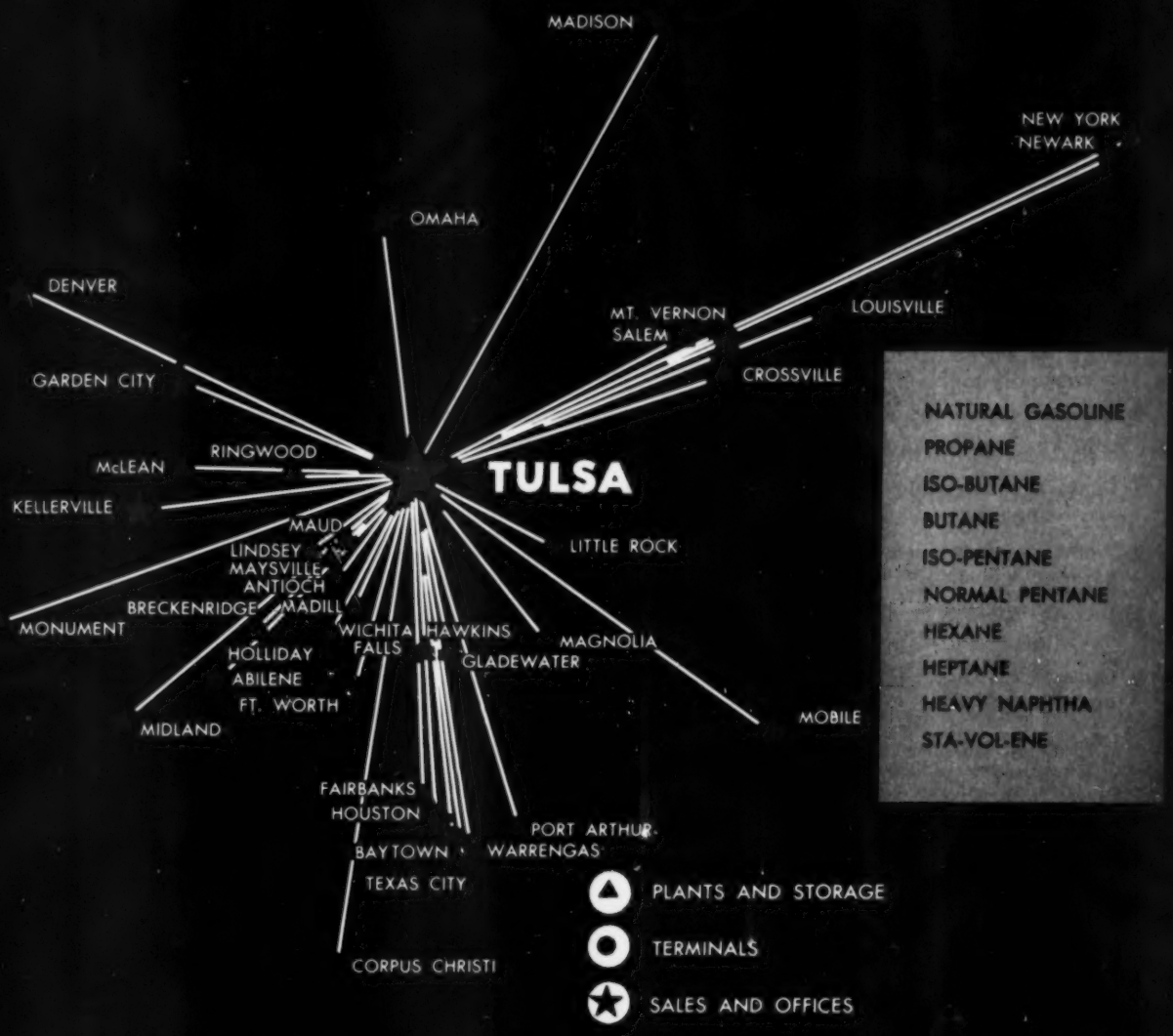
SYNTHETIC METHANOL; FORMALDEHYDE: The climatic conditions in western Canada are such that it is doubtful that methanol can be used successfully in large quantities as an antifreeze. The other large use for methanol is for conversion to formaldehyde. A market for the latter rests on two possible prospects: the large scale local production of plastics, particularly of the urea-formaldehyde type; or, in case of war, production of explosives using formaldehyde in the manufacture of pentaerythritol and hexamthylene-tetramine.

HYDROGEN CYANIDE: HCN is primarily useful as a chemical intermediate in the synthesis of acrylic resins, plexiglas, and orlon (via acrylonitrile). Its large-scale production in Alberta would have to accompany further development of a plastic and synthetic fiber industry. Alberta already has a start in that direction and the long-range outlook for the development of related industries using HCN is decidely favorable.

BUTANE-BUTYLENES-BUTADIENE: The synthetic rubber industry is continuing to use large quantities of butane from natural gas, amounting to some 200

• See Canada page 96

Service



NATURAL GASOLINE
PROPANE
ISO-BUTANE
BUTANE
ISO-PENTANE
NORMAL PENTANE
HEXANE
HEPTANE
HEAVY NAPHTHA
STA-VOL-ENE

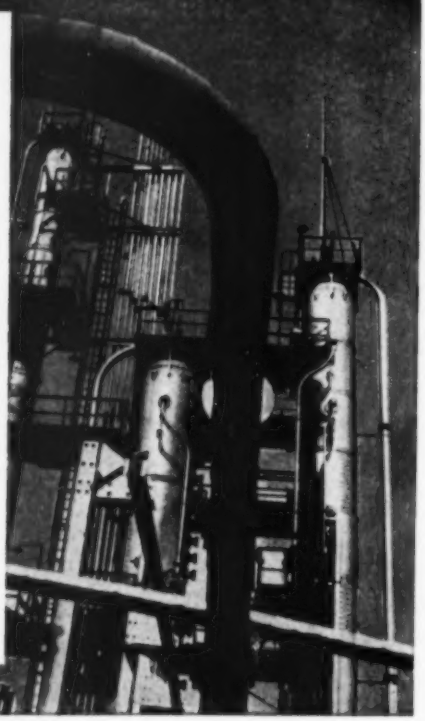
WARREN

PETROLEUM CORPORATION

TULSA, OKLAHOMA CABLE ADDRESSES: Stanolind, Warren

EXTRACTION PLANTS: CORPUS CHRISTI, PORT ARTHUR, BAYTOWN, TEXAS CITY AND WARRENGAS, HOUSTON, TEXAS

YOU CAN STOP liquid carry-over in processing vessels WITH METEX MIST ELIMINATORS



The unusually high efficiency with which these *knitted* wire mesh units remove the liquid entrainment that occurs in a wide variety of refining and processing operations has enabled engineers to:

1. Improve product quality and eliminate reruns.
2. Prevent contamination in subsequent operations.
3. Recover valuable products previously lost.
4. Operate existing equipment at higher capacities.
5. Design new equipment with smaller dimensions.
6. Achieve more economical processing of lower grade materials.
7. Secure longer "on-stream" periods by removing corrosive liquids.
8. Prevent air pollution by objectionable liquids.

METEX Mist Eliminators can be used *wherever* the problem of liquid entrainment exists. By effecting complete removal of liquids, Mist Eliminators contribute to more efficient and economical processing in such vessels as:

VACUUM PIPE STILLS	EVAPORATORS	COMPRESSORS
FRACTIONATING TOWERS	ABSORBERS	SEPARATORS
KNOCK-OUT DRUMS	SCRUBBERS	STEAM DRUMS

Get the full facts on METEX Mist Eliminators

Write for bulletins giving detailed information — including limiting velocities, pressure drop, efficiencies, etc.

METAL TEXTILE CORPORATION

KNITTERS OF WIRE MESH FOR MORE THAN A QUARTER CENTURY

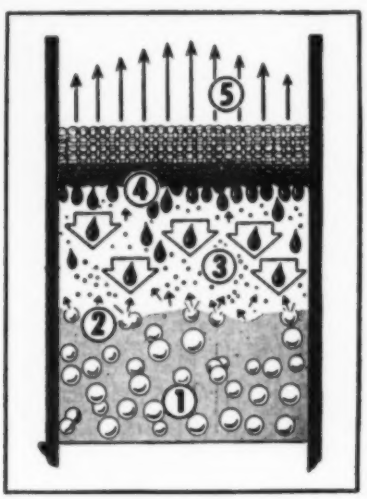
Main Office & Plant, Roselle, New Jersey — Canadian Plant, Hamilton, Ont.

Pads of Knitted Wire Mesh Wipe Out Liquid Entrainment

Pads of uniform density, made from multiple layers of knitted wire mesh, have proved exceptionally effective in removing liquid entrainment from gases in a wide range of refining and processing operations.

The pad is placed inside a vessel above the liquid level. Its construction provides a multiplicity of unaligned, asymmetrical openings with unusually large wire-surface area. It is impossible for a gas to pass through the pad without continually changing direction; yet the high free volume—97 to 98%—minimizes restriction and pressure drop.

Method of Operation



When a gas is generated in or passes through a liquid (1), it carries with it, as it bursts from the liquid surface (2), a fine spray of droplets of entrained liquid. These droplets are carried upward by the rising gas stream (3).

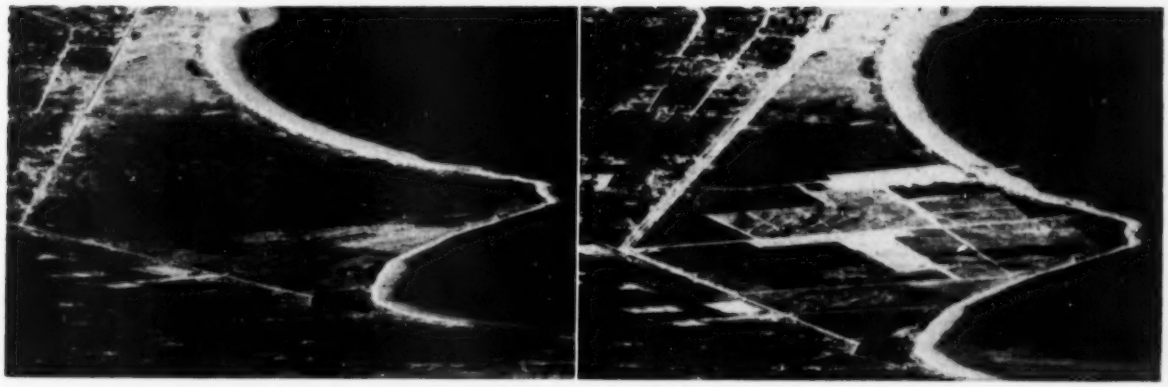
As the gas passes through the pad, the droplets impinge on the extensive wire surface (125 square feet of area per cubic foot of pad volume). The droplets coalesce on the wire surface to form large drops of liquid which break away (4) from the wire mesh and fall back against the gas stream. The gas (5) passes on, freed from liquid entrainment.

Availability

The pads, which are known as METEX Mist Eliminators, are made by Metal Textile Corporation, 633 East First Avenue, Roselle, N. J. A bulletin giving detailed information is available on request from the manufacturer.

(Adv.)

WHO'S Building . . .



BEFORE . . . . AFTER

Period of 15-weeks work makes a difference at Kwinana refinery project, Fremantle, Australia

Good Progress Reported on Anglo-Iranian's 60,000-Barrel Refinery in Western Australia

Work on the permanent jetty at the new 60,000-barrel-a-day refinery of Anglo-Iranian Oil Company at Kwinana, Western Australia, will get underway this month, marking another step in construction of Australia's largest refinery. A fleet of more than 40 small vessels and rafts is being assembled for the job, which follows by about nine months the day work started on the refinery. The 2700-foot concrete and steel jetty will have three tanker berths.

Site preparation work has been going on at Kwinana since last April, when foundations were poured for the first permanent refinery structure. All phases of construction—a "combined operation" in the wildest sense—are now underway.

1955 Completion

The refinery is scheduled to come on stream in 1955, at which time it is expected to supply the equivalent of about 40 percent of Australia's petroleum requirements. The plant will include two atmospheric distillation units complete with stabilizers, solutizers and soda washers; a vacuum distillation unit; a catalytic cracking unit; a hydrofining unit; and a platforming unit. Two pipe lines, one for black and the other for white oils, will link Kwinana with existing installations at Fremantle, which is nearby.

Prime contractors for the project are The M. W. Kellogg Company of America with its subsidiary, Kellogg International Corporation, of London. Kellogg has subcontracted the construction to British contractors who have established a subsidiary company in Australia known as Kwinana Construction Group. This organization represents Costain-John Brown, Ltd., D. C. and William Press, Ltd., and Kinnear Moddie, Ltd.

As much as possible of the work on the refinery is to be done by Australian firms and Australian workers. Subcontracts let to Western Australian firms for preliminary work on the site so far total approximately $755,000. More than 300 men are employed on these jobs, most of which are ahead of schedule.

Since work began on the 950-acre site, bull-dozers, graders and other mechanical equipment have been carving out roads (see above) and levelling areas for buildings. Most of the refinery area has been cleared and the four-mile perimeter fenced. About nine miles of permanent roads have been formed.

A construction camp, complete with mess hall, laundry, and recreation facilities, is ready for occupation by 400 men. Other buildings erected include a warehouse, cement store, offices, workshops, and various small area buildings.

Since last October, more than 9000 tons of construction material and equipment, plus nearly 2000 tons of installation material from the United Kingdom, the U. S., and the eastern states of Australia, have been landed at Fremantle and taken to the refinery site by road. About 75,000 tons of material and equipment will pass through Fremantle before the refinery is completed.

Complementary with the activity on the refinery site, work on the building of a township has been started two and a half miles away. More than 100 houses are under construction at the township, at which many of the refinery's permanent staff of 1200 will live.

Sunray Will Hike Recovery Of Propane at Snyder Plant

Additional processing facilities to increase propane recovery will be installed at the Snyder, Texas, gasoline plant of Sunray Corporation, the Snyder plant advisory committee has announced.

An additional absorber and other equipment which will increase propane recovery to 76 percent while handling 75 Mmcf of natural gas a day will be installed. Initial design of the plant called for 70 percent propane recovery while handling 50 Mmcf of gas a day. When the new installation is completed, the plant's total liquid production should be approximately 625,000 gallons a day.

Four Major Refining Projects Head ODM Fast Tax Write-Offs

Four major refining projects head the latest list of petroleum projects approved for rapid tax write-off by the Office of Defense Mobilization. They are:

The new $25 million basic refinery which Pan American Refining Corporation will build at Podricktown, N. J., to process approximately 25,000 barrels a day of crude oil. Rapid write-off will apply to 65 percent of $11,512,000 in basic facilities, 45 percent of $12,640,000 in auxiliary facilities and 15 percent of $1,000,000 for buildings.

The $11,390,000 Suntide Refining Company plan to increase alkylation facilities and to double the present 25,000-barrel-a-day crude oil capacity at its plant near Corpus Christi, Texas. The 100 percent rate was granted on $1,100,000 in alkylate facilities, 65 percent on $7,465,000 in basic refining and 45 percent on $2,825,000 in auxiliary facilities.

The Texas Company's plan for avgas and basic refining facilities at Westville, N. J., costing $12,500,000, with a rate of 100 percent on $4,162,000 for avgas facilities, 65 percent on $4,538,000 in basic refining and 45 percent on $2,800,000 in auxiliary facilities.

Signal Oil & Gas Company's $9,568,500 natural gasoline plant at Tioga, N. Dak., with $6,318,500 certified at 65 percent and $3,250,000 at 40 percent.

Other petroleum projects approved, with name of company, location of facility, type of facility, amount allowed and percentage rate, were:

Duncan Products Company—Duncan, Okla., petroleum refining, $3,198,000 at 65 percent; $749,200 at 45 percent.

Sunray Oil Corporation—Duncan, Okla., refining, $1,785,000 at 65 percent.

Hancock Oil Company—Long Beach, Calif., refining, $3,050,000 at 65 percent; $450,000 at 45 percent.

Allied Chemical & Dye Corporation—Painesville, Ohio, sulfuric acid, $3,300,000 at 45 percent.

Esso Standard Oil Company—Baton Rouge, La., aviation alkylate, $549,000 at 100 percent; $290,000 at 20 percent.

Humble Oil & Refining Company—Baytown, Texas, specialized facilities for aviation gasoline, $140,000 at 100 percent.

Mid-Continent Petroleum Corporation

WHO'S Building . . .

—Tulsa, aviation alkylate, $433,428 at 100 percent.

Continental Carbon Company—Eunice, N. M., natural gasoline, $500,000 at 40 percent; $1,879,000 at 65 percent.

Douglas Oil Company of California—Bakersfield, Calif., petroleum refining, $605,000 at 65 percent.

SUNRAY Oil Requests Bids On Construction of Coking Unit

Refinery engineering contractors have been asked to submit bids for the construction of Sunray Oil Corporation's 9000-barrel-a-day delayed coking unit to be built at Duncan, Okla., in conjunction with Sunray's 25,000-barrel-a-day refinery with catalytic cracking facilities operating at that point.

Construction is expected to start on the new plant in August, with completion scheduled in the fall of 1954. The installation will be planned, engineered and operated by Sunray for Ucan Products Company, a recently organized corporation in which Sunray has a 50 percent stock ownership.

Sunray has received a certificate of necessity from the Commissioner of Internal Revenue to amortize 60 percent of the approximately $4 million to be invested over a five-year period. The write-off was granted because the petroleum coke to be produced in the new plant will be used predominantly for defense purposes.

In addition to the raw petroleum coke which the plant will manufacture, Sunray will also produce fuel gas, propane-propylene, butane-butylene, debutanized gasoline and gas oil for catalytic charging stock through the new installation. The coker gasoline and catalytic charging gas oil stock will be charged back into Sunray's catalytic cracking unit to produce up to 7000 barrels a day of commercial fuel products, including high quality gasoline, gas oil, butane and propane.

ARAMCO Ups Production In 1952 at Ras Tanura Plant

More oil was refined in Saudi Arabia during 1952 than during any other year since the Ras Tanura refinery began operation in 1945, according to Arabian American Oil Company's publication, "Aramco-World."

The refinery runs in 1952, the booklet reports, totaled 62,204,161 barrels, reflecting an increase of more than four million barrels over the 1951 figure. The 1952 run also represented an increase of 20 times the output registered during the refinery's first year of service only seven years earlier, the annual report section of the magazine notes.

Among the new units added to Aramco's facilities last year, the report goes on, where five gas-oil separator plants. These plants relieve the gas pressure from crude oil. Saudi Arabian oil has a high gas content which creates a great pressure underground.

Crude oil production last year amounted to 301,860,885 barrels, an increase of 23,898,280 barrels over the previous two-month period. The average daily output during 1952 was 824,756 barrels, according to the report.

Ohio Oil and Cosden Join in Plan To Increase Nation's Alkylate Output

Latest companies to join in the government's drive to increase the country's alkylate-making capacity are The Ohio Oil Company and Cosden Petroleum Corporation.

The Ohio Oil Company will add 1500 barrels a day to the government's intensified drive to boost production of the aviation gasoline component. The contract is being cleared through the Armed Service Petroleum Purchasing Agency, which administers the $80 million authorized by Congress for underwriting production or keeping plants in a stand-by condition for five years.

PAD reported that Ohio Oil will build the $1.8 million plant at its Robinson, Ill., refinery. This will bring the total expansion contracted for to 8073 barrels a day of maximum capacity, including the use of outside feed stocks if the need arises.

Ohio's plant is the fifth in the joint PAD-Defense Department drive to hike avgas production. Government petroleum experts hope to add a total of 31,000 barrels a day in capacity to the nation's alkyline supplies through purchase contracts similar to Ohio's, in which the government agreed to buy the plant's entire output for five years if Ohio can't sell it to other buyers. PAD officials said about a dozen other oil companies are negotiating with them for possible construction of other alkylate plants.

Cosden Petroleum Corporation, sixth company to sign an alkylation facility and supply contract under the military expansion program, will build facilities for producing 1800 barrels a day of aviation alkylates at its Big Spring, Texas, refinery. As was the case with Ohio Oil's planned project, the Armed Service Purchasing Agency handled the contract. This addition will provide an output of 2300 barrels a day of grade 115/145 avgas, the agency said.

With the signing of Ohio Oil and Cosden, the total design capacity of all contracted units was brought to 10,600 barrels a day, or 9870 barrels a day of "normal" capacity. ASPPA and PAD are still seeking an additional 24,000 barrels a day to meet the program's goal.

Companies which previously signed are: The Pure Oil Company, Eastern States Petroleum Company, Globe Oil & Refining Company and Sunray Oil Corporation.

Italian Refineries Given Approval For Increase in Production Facilities

A number of applications for expansion of existing refinery capacity in Italy have been granted by the Italian Ministerial Commission. New authorized capacities are as follows with authorized capacity comparison for the end of 1952:

Company	New Authorized Capacity (Figures in metric tons followed by approximate barrels-a-day figures in parentheses)	Authorized Capacity 1952
Aquila refinery (Trieste)	1 million (19,000)	600,000 (11,500)
Condor refinery (Rho)	1.4 million (27,000)	1 million (19,000)
Esso refinery (Trieste)	300,000 (5750)	150,000 (2900)
Garrone refinery (Genoa)	500,000 (9600)	150,000 (2900)
Ilsea refinery (Lecco)	90,000 (1700)	50,000 (960)
Lombarda Petroli refinery (Villa Santa, Sardina)	200,000 (3800)	160,000 (3100)
Sarpom refinery (Trieste)	1 million (19,000)	650,000 (12,000)
Sianic refinery (Bari)	1.4 million (27,000)	500,000 (9600)
Socony-Vacuum Italiana refinery	3.1 million (59,000)	1.3 million (25,000)

LION OIL Chemical Plant Will Go on Stream in 1954

Lion Oil Company's Barton chemical plant, which is under construction near New Orleans, is not expected to go on stream until the second quarter of 1954. The $31 million installation will use natural gas, air and water to synthesize 300 tons of anhydrous ammonia per day. Largest portion of the ammonia will be further synthesized to pelleted ammonium nitrate.

PAD Issues Revised Estimates Of Future Refining Capacity

Crude-oil refining capacity in the U. S. is expected to reach a total of about 8,100,000 barrels a day by the end of 1953 and about 8,400,000 barrels a day by the end of 1954, according to revised estimates made public by Petroleum Administration of Defense.

An additional 62,000 barrels a day of

■ See PAD, Page 181

Construction **Boxscore** Starts on Page 193

There is only one, and he is HOME ASLEEP!

In this self-sufficient plant the "Operators" are built into the plant — a human operator is required only for loading products and routine maintenance. During the night unusual changes in pressures or levels cause the warning ringing of the bedside telephone of the resident operator.

The plant, operating in the Ropes Field of Hockley County, West Texas, is designed to compress and dehydrate 4 million cubic feet of gas per day, extract 67% of the propane, and produce three liquid products totaling 35,000 gallons per day.

The special features to reduce operating costs and minimize capital investment without sacrifice of propane recovery, safety or continuity of operation were developed by HUDSON in collaboration with the engineers of Honolulu Oil Corporation to solve the problem of economically processing small quantities of rich gas.

General view of plant showing HUDSON Combin-aire unit at left.

HUDSON
ENGINEERING CORPORATION
FAIRVIEW STATION • HOUSTON, TEXAS

Canada's Petrochemical Outlook Tied in with Natural Gas Supply

• CONTINUED FROM PAGE 90

million gallons yearly since 1950. Butadiene from natural gas and petroleum sources is less costly than from ethyl alcohol. In the U. S., butadiene is made chiefly from refinery gases produced in conjunction with catalytic cracking operations. Canada, likewise, bases her synthetic rubber production on refinery gases. However, as Canadian needs increase it may very well be that alternative sources of C_4 hydrocarbons will have to be found. In that case the establishment of a synthetic rubber industry in Alberta, based on styrene from petroleum, carbon black from oil or natural gas, and butadiene from butane, would be a logical development.

To overcome the distant marketing problems, a $270 million natural gas pipe line, connecting Alberta and Quebec is expected to be under construction by summer, 1953.

OXYGENATED ORGANIC COMPOUNDS: The various aldehydes, ketones, acids and alcohols obtainable by the partial oxidation of butane, are used primarily as chemical intermediates. Canadian Chemical Company's plant at Edmonton, Alberta, is to emphasize the production of acetic acid by a partial oxidation process, and the acid will then be used for making cellulose acetate from wood pulp which is to be shipped from British Columbia. The fact that a synthetic fiber plant of this type can be profitably located in Alberta is a most encouraging sign on the marketing scene.

NON-HYDROCARBON PETROCHEMICALS, SULFUR: Hydrogen sulfide in natural gas may in certain cases be profitably extracted and marketed. The market for sulfur in western Canada is rather limited, and high transportation costs would probably rule out any eastern Canadian markets. However, with expectation of higher sulfur prices, Alberta sulfur should be able to compete on the Canadian Pacific Coast and possibly in the American Pacific northwest.

Doubtful Outlook

The following seven classifications of petrochemicals from natural gas do not stand to fare so well on the Canadian market:

CARBON BLACK: *Channel Black.* Since initial investment costs for plants are comparatively low, and since the Canadian market must be met by importation, there has been considerable interest in the production of carbon black from Alberta natural gas. However, several factors militate against the immediate establishment of a channel black industry in Alberta, especially the long freight haul to eastern Canadian markets, the severe climatic conditions which require sturdier plant construction than American plants in Texas, and the uncertain future of natural rubber. In addition, the policy of the Alberta Government, which operates through the Petroleum and Natural Gas Conservation Board, must be taken into account. The board, it is believed, takes a view that the channel process with its low conversion efficiency (3 to 5 percent of theoretical) does not represent efficient utilization of the gas.

Furnace Blacks. The general comments made about channel black apply here also, although the higher conversion efficiencies (30 to 40 percent of theoretical) suggest that the furnace processes would be favorably looked upon by the Conservation Board. For supplying synthetic rubber needs in eastern Canada, oil blacks produced on the scene would probably hold an economic advantage. Cabot Carbon Company's $2 million oil furnace-black plant at Sarnia, Ontario, tends to confirm this belief.

SYNTHETIC FUELS: The Fischer-Tropsch process appears to be one of the "long-term" solutions to the problem of liquid fuels. Prior to the discovery of oil at Leduc, Alberta, in 1947, the larger oil companies operating within the province were considering the possibilities of producing synthetic oil from natural gas. It now seems unlikely, in view of the present success in oil exploration, that synthetic plants will be required in Alberta for many years unless needed to meet a national emergency.

PROPANE-PROPYLENE: There is at present no large market in Alberta for propylenes or products derived from propylene. There is, however, the possibility of producing high value products from propylene which could compete favorably in the eastern Canadian market. Although ethylene may be produced from propane, a much larger source is the ethane fraction of natural gas.

NITROPARAFFINS: Commercial quantities of these petrochemicals-from-natural gas have only recently been made available, and the market is not completely developed. Nonetheless, while both low cost propane and low cost nitric acid (from the ammonia plant in Calgary) are available in Alberta, it is believed that the Canadian market for nitroparaffins is too small for commercial exploitation.

HELIUM: Approximately 1.5 percent of helium exists in natural gases in American fields. Alberta's natural gas is considerably less than these and therefore do not warrant commercial production at this time.

CARBON DIOXIDE: Even in the case of gas wells with a high carbon dioxide content, it is doubtful if the carbon dioxide could be profitably extracted. There is at present in Calgary, a large by-product carbon dioxide production from the ammonia plant which could more than saturate the existing market.

NITROGEN: Economically, nitrogen recovery from natural gas appears out of the question. In special cases the nitrogen might be removed from certain natural gases, but this would be for another reason—to increase the heating value of the gas and thus reduce transportation costs per unit of heat.[1]

Although this report has dealt only with those petrochemicals which can be derived from natural gas, a comprehensive picture can be shaped regarding Alberta's role in Canada's chemical future.

Conclusion

Although this report has dealt only with those petrochemicals which can be derived from natural gas, a comprehensive picture can be shaped regarding Alberta's role in Canada's chemical future. Naturally, it is expected that the petrochemical industries will continue to draw their raw materials both from natural and refinery gases. Already certain synthetic fibers, many plastics, certain explosives and fertilizers are now being made in the province, and their production will no doubt see considerable expansion.

LITERATURE CITED

[1] Research Council of Alberta, "Chemical Utilization of Natural Gas," by D. Quon and G. W. Govier.

LUBRICANT—
THE NORDSTROM SEAL OF APPROVAL

In any valve, if a small leak starts, high repair and replacement costs are coming up. And, if the valve is in an often-operated manifold, trouble comes to a head sooner.

Unless . . . .

. . . . the valve is a Nordstrom.

Nordstrom valves have an extra seal against those small leaks. In Nordstrom valves, an even film of plastic lubricant surrounds the valve ports, sealing off the line fluid and at the same time filling any minute point of wear. Further, since there is no seat or disk in the eroding stream of flow, the chances for wear are cut to a minimum.

It's that extra seal of lubricant that has won approval for Nordstrom valves in hundreds of services where other valves aren't quite good enough.
Rockwell Manufacturing Company, Pittsburgh 8, Pa.

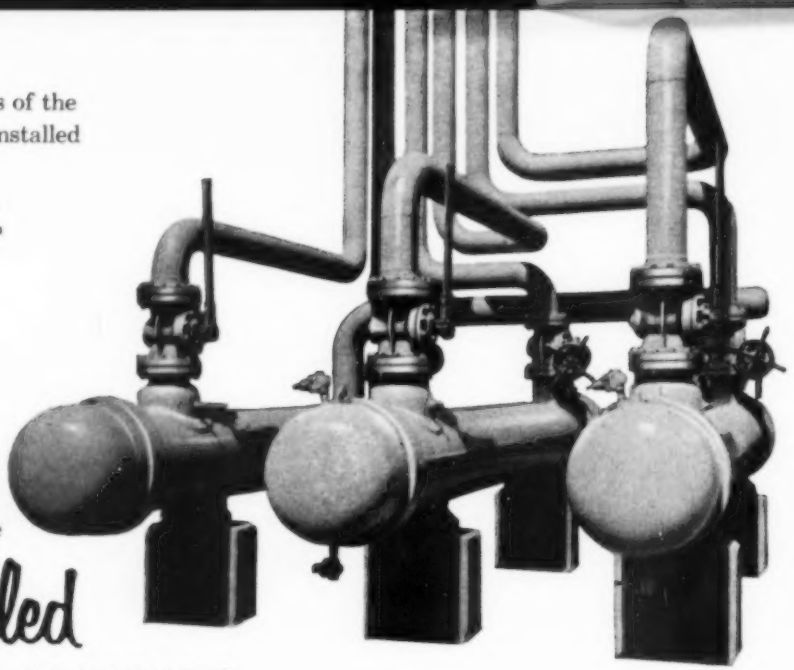
ROCKWELL Built Nordstrom Valves

Lubricant-Sealed for Positive Shut-Off

Another Rockwell Product

Regardless of the process, regardless of the piping arrangement, all valves are installed to do the same job:

TO CONTROL FLOW



Some valves do the job better than others. Some valves operate more easily than others in an emergency. Some valves stay tighter longer than others. That's because some (like these) are

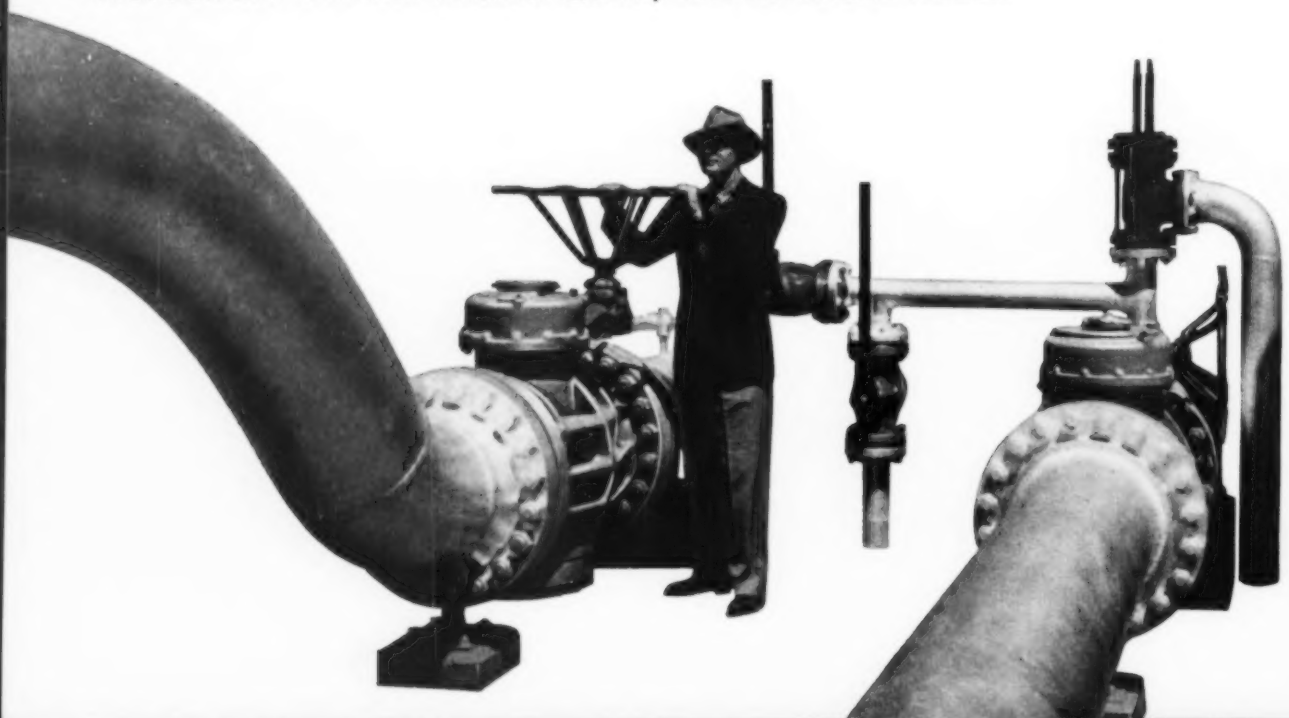
Lubricant-Sealed NORDSTROM VALVES

Nordstrom valves have a built-in lubricating system. The lubricant does two important things—it keeps the plug easy to turn so the valve shuts and opens in an instant when it is supposed to; it seals against the small leaks that become big and expensive and perhaps dangerous.
That's why Nordstrom valves

ARE YOUR BEST BUY

Rockwell Manufacturing Company, Pittsburgh 8, Pa.

Nordstrom Valves Another Quality **ROCKWELL** Product



FUEL OIL REDUCTION SYMPOSIUM

Foreword

A SERIOUS crisis is being faced by many refiners. Hardest hit are the smaller companies operating at inland locations without easy access to marine shipping. The problem: **How can a company operate profitably in the face of the current low price of fuel oil?** As with all really tough problems, there are many facets to the situation and as many answers. None of the answers are easy ones and much depends on the refiner's individual situation. This symposium was developed to bring the problem into focus and highlight those solutions which are the most applicable.

First, what has happened to the fuel oil market? Why has the demand for this product not kept pace with the demand for other petroleum products which have seen a 37 percent increase in the last five years? There are two significant answers to the market price problem. Consumption has not materially increased due to the increasing competition offered by other energy sources. For example, consumption by railroads has decreased 45 percent in the last five years because of the economic attraction of diesel fuel. Natural gasoline is making inroads into the fuel oil market and this trend is certain to progress even more rapidly in the future. Hydroelectric facilities have developed as important competitors to fuel oil.

A second—and difficult to evaluate—influence on the fuel oil market price has been the rapidly burgeoning increase in the rate of fuel oil imports. These have increased from 122,000 barrels per day in 1946 to 325,000 barrels per day in 1951—almost tripled. These imports now represent about 20 percent of the total U. S. supply of fuel oil. This is not the time nor place to attempt to explore a highly controversial issue that has so many political and economic implications. Suffice to say that imports have greatly increased and are certain to have had a measurable effect on the market structure of fuel oil.

Is there any way that the industry as a whole can team up to whip the problem? PETROLEUM REFINER thinks there is and herewith present our case.

Question: who is having the greatest difficulty because of the fuel oil problem? Answer: the small inland refineries. Question: why are they having more trouble than the larger refineries? Answer: two reasons—lack of the proper type of equipment to convert fuel oil into more salable products, and lack of coastal shipping outlets. Question: can the *larger* refiners do anything about this? Answer: yes!

Here is what we propose: the larger refiners should buy at least a part of the production of the small refiners and convert it to gasoline in their more elaborate equipment. This would not be a charitable undertaking but would constitute a low-to-medium profit operation. The small refiners' fuel oil is rich in gasoline—often as high as 20 to 25 percent. Thus reprocessing yields would be very good. The chief drawback is the small quantities that must be handled which might place the whole operation in the category of nuisance business. However, what constitutes a "nuisance" for the large refiner is "life-or-death, sink or swim," for the small refiner. We are pleased to report that at least two major companies are now engaged in this very activity of lending a helping hand to their small refiner kinsman—and at no loss to themselves. There is still much to be done. We strongly urge that the larger companies survey the situation, and do their part. Politically and economically, they are assured of a fair return on their effort.

The above recommendation is an emergency measure designed to allay but not solve the problem. The American economy is based on the stern unyielding law of survival of the fittest, compete or close up. Therefore steps must be taken immediately to adjust the individual refiners' operations in regard to the long range fuel oil picture. There are two approaches: reduce fuel oil production to the minimum and then install proper equipment to convert a portion of the remainder to more salable products. That is the reason for this symposium.

On the next 12 pages you will find a review of the latest processes for upgrading fuel oil. In addition there are timely and practical suggestions offered for adjusting current operations toward more favorable yields. Large or small, you will profit from a careful study of this symposium.

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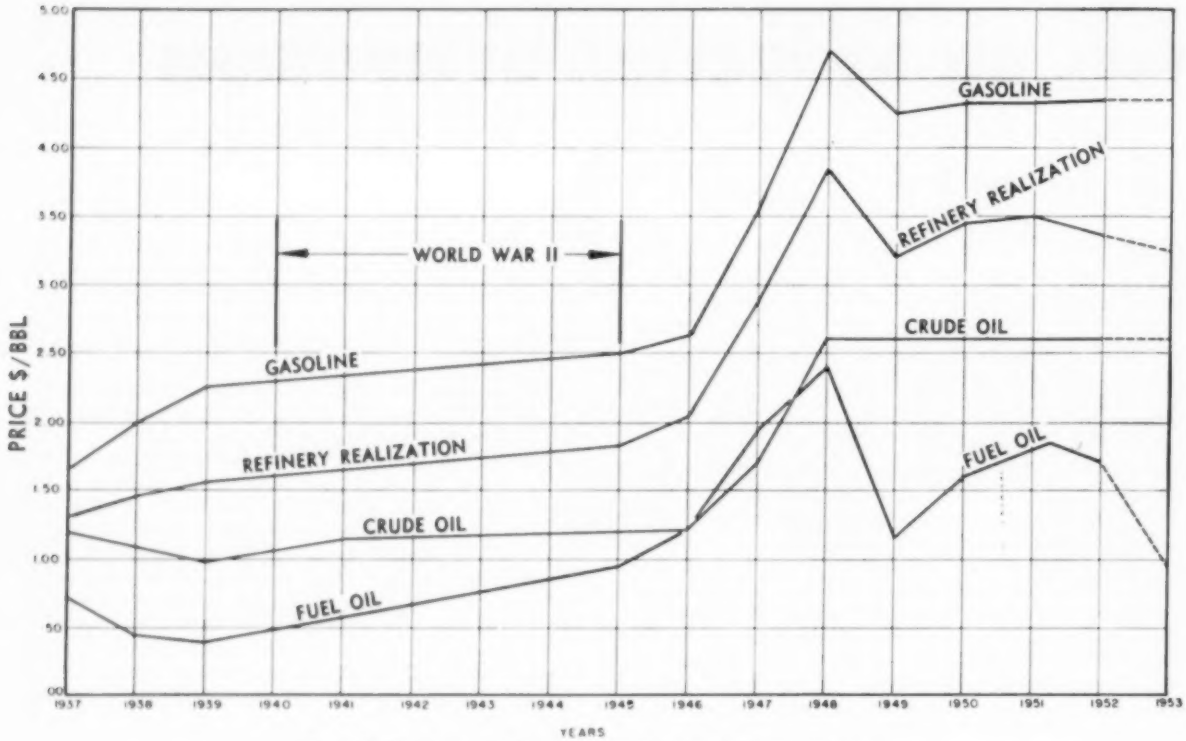

Figure 1. Trends in product realizations for Mid-Continent refineries.

Critical Economic Factors of

Reducing Fuel Oil By Residuum Coking

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ALERT REFINERS REACT quickly to market trends affecting their economic position. A rapidly developing—and ominous—situation requiring their immediate attention is the weak position of the fuel oil market. There are two apparent solutions to the problem: regulatory legislation by the government to stimulate artificially the price of fuel oil, and the installation of new processes that will transform fuel oil into more profitable and salable products. The most promising of these processes is residuum coking. The purpose of this paper is to trace the development of coking processes, analyze the economic incentives for their installation, and predict the future of the market for petroleum coke.

DEVELOPMENT OF THE PROCESSES. From the earliest thermal cracking, coking has been with us. First attempts at cracking of petroleum were conducted in batch shell stills such as the famous Burton stills installed at the Whiting, Ind., refinery of the Standard Oil Company (Indiana). Coking at that stage of the development of the refining art was largely a nuisance and safety problem; coke removal being effected by pick and shovel, and overheating of the still bottoms occasionally causing disastrous fires such as occurred in Whiting in 1922. Decoking in shell stills was usually accomplished by a black gang which went in with pickaxe, hammer and chisel and shovelled the coke out the open manway.

When coil cracking of petroleum started taking over from shell still cracking about 1920, the coke made in the cracking process accumulated to a major extent in the reaction chambers which at that time consisted of horizontal pipe in series.

About 1922 vertical chambers were added to commercial units, which at that time required gravity feed to the

Fuel Oil Reduction

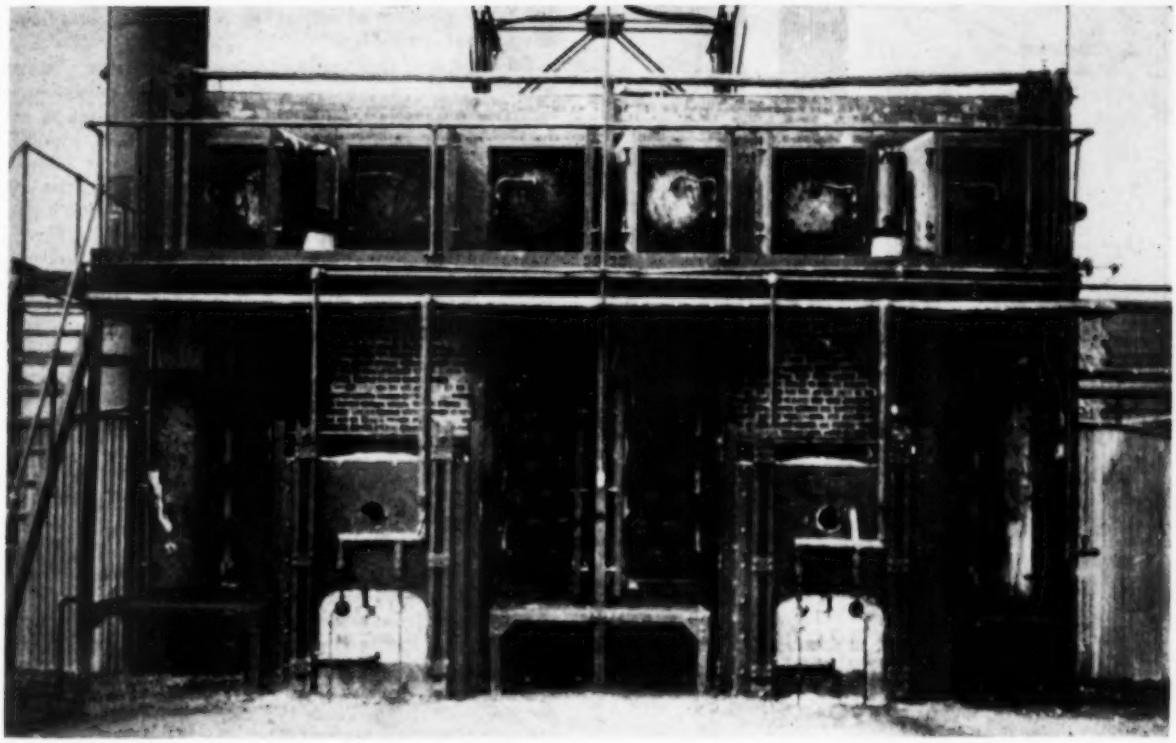


Figure 2. View of first commercial Dubbs unit showing horizontal reaction chambers.

The decreasing market price of fuel oil warrants a searching look at methods of reducing production. Coking processes are analyzed from the standpoint of

- **Development of coking processes.**
- **Economic incentives for new investment.**
- **Market potential for petroleum coke.**

cracking coils, produced coke in significant and troublesome quantities, resulting in runs of short duration and frequent shutdowns for cleaning.

As substantial quantities of cracked fuel oil were made by Dubbs and similar thermal cracking processes, this fuel oil periodically became a glut on the market, and represented a significant loss to the refiner because of low price, or a staggering storage problem. In the mid-thirties systematic attempts were made to convert the cracked residuum to coke in order to minimize fuel oil production, and the delayed coking process in the first variant of the form in which we know it now was born. This process was basically an extension of the reaction chamber principle except that the reaction or coking chamber was so designed as to accumulate substantial quantities of coke between cleanings and the plant incorporated one of several devices for the removal of the coke from the drum. These devices ranged from pick and shovel through pulling chains and decoking cables.

The refiners have known for a long time how to produce coke. Thus to develop a successful coking process it was necessary only to have a method for decoking. In the late twenties the Hughes Tool Company developed a drilling unit for removing coke from vertical drums. This unit first drilled a small hole through the coke bed, then balls and chain were fastened to the drill stem, and the coke beaten out of the drums. Later, this method was modified by using a large bit that would drill out the drums.

In the mid-thirties the hydraulic decoking process was developed by W. F. Court and came to the fore as a means commercialized by Allen-Sherman-Hoff and Worthington. First installation was at Shell, Wood River, Ill., in 1938. The hydraulic decoking operation was widely applied to coking plants and afforded a reasonably attractive solu-

Fuel Oil Reduction

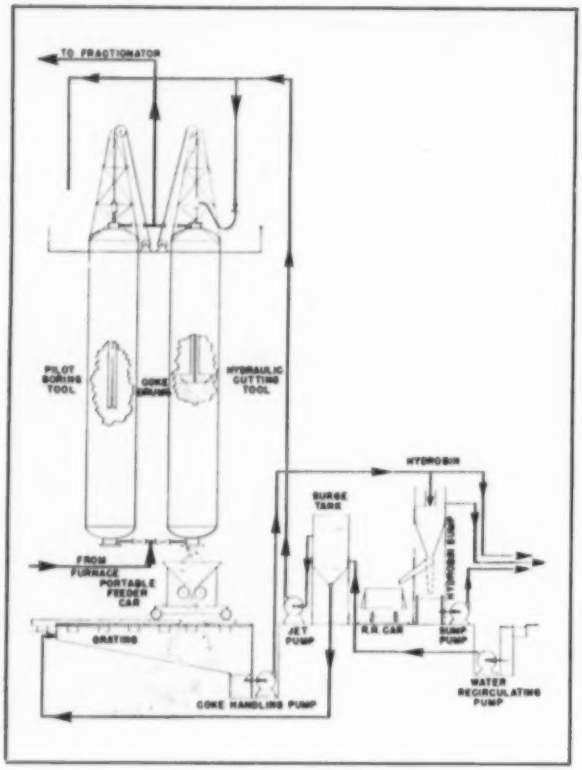


Figure 3. Schematic Flow Diagram of Hydraulic Decoking system.

TABLE 1

Economics for Blow-Knox Decarbonizing Process

CHARGE: 10,000 B/D 26° API East Texas Reduced Crude

Investment $1,000,000

	$/Day	¢/Bbl.
Operating Costs:		
Utilities (steam, fuel, power, and water)	286.00	2.86
Labor: Operating, decoking and supervision	220.00	2.20
Taxes and Insurance (3% of investment)	82.00	.82
Maintenance (5% of investment)	138.00	1.38
Administration and Overhead (80% of labor plus maintenance)	322.00	3.22
Amortization (15 years)	183.00	1.83
Total	$1,231.00	12.31
	Quantity	**$/Day**
Value of Products*:		
Gas	825 MSCF/D	82
Gasoline	563 B/D	2,130
Gas Oil	9,060 B/D	29,100
Coke	79 T/D	394
		$31,706
Value of Decarbonizer Charge Stock:		
Value of Products	$31,706	
Less Operating Costs	1,231	
Net Value of Reduced Crude	$30,475	
Value per Barrel of Reduced Crude	$ 3.05	

*Basis:

Gas	10¢/MCF
LPG	5¢/Gal.
Gasoline:	
Coker	9¢/Gal.
Cat. Cracked	11.5¢/Gal.
Poly	11.5¢/Gal.
Light Cycle Oil	7¢/Gal.
Heavy Cycle Oil	95¢/Barrel.
Coke	$5.00/Ton

Fuel Oil Reduction

tion to the problem of getting the coke out of a large coke drum (see Figure 3).

The economic justification for coking is tied in with the refiner's margin which is the difference between the weighted refinery net back prices for refined products and the cost of the crude oil charged to the refinery. Figure 1 shows the history of the average mid-continent refiner's margin for the last 15 years. Superimposed on the two curves for weighted net back and crude oil price are curves for the gasoline sale price and fuel oil sales price for the corresponding periods of time. It can be seen that over the past 15 years the refinery has always made money on gasoline but has lost money on fuel oil except for a short period after World War II. Also, the trend line for 1953 has ominous economic significance. The problem, therefore, is to find a coking process which will convert a maximum amount of fuel oil constituents, including distillate cutter stocks, into high yields of profit-making products at minimum investment and operating cost.

Considerable effort has been devoted to developing a coking process more applicable to modern refining needs. For example, the Curran Carbonizing Company of St. Louis offers a process involving a floor fired horizontal coking chamber, somewhat similar to a Kopper's by-product coking oven turned on its side. This coking furnace, derived from a similar type of furnace used in coking of coals, has been installed in South America. This process appears to have greatest applicability to situations where extremely heavy pitch is or can be made available as charge to the process, and where a premium price is obtainable for the low volatile, high strength, metallurgical grade coke produced.

We are sure that all of the refining industry has followed with great interest the developments of the Continuous Contact process. This was first reported in literature in 1949, and the initial research work showed such promising results that a fairly large scale pilot plant was built and successfully operated. The first commercial

TABLE 2

Appraisal of Coking Vs. Fuel Oil

INVESTMENT

Delayed Coker	$2,200,000
Fluid Cracking Unit	1,500,000
Thermal Cracking	600,000
Sub-Total	4,300,000
Other Facilities	1,500,000
Total	$5,800,000

ECONOMICS APPRAISAL

	Increase for Coking Dollars per Year
Realization*:	
Gasoline	7,140,000
Cracked Fuel Oil	440,000
Fuel Gas	340,000
Coke	530,000
	$8,450,000
Costs:	
Topped Crude	4,110,000
Delayed Coking	300,000
Catalytic Cracking	305,000
Thermal Cracking	180,000
	$4,895,000
Gross Profit	$3,555,000
Net Profit (52% Tax)	$1,900,000
Payout After Taxes	3.0 years

* Fuel Oil—$1.50 per barrel. Regular Gasoline—10 cents per gallon.

TABLE 3

Where Coke Goes

INDUSTRY	Percent Used
Aluminum Smelters	20
Electrode Manufacturers	7
Steel	10
Chemical	1
Calcium Carbide	1
Refractories & Abrasives	2
Fertilizer	2
Export	5
Fuel at Refineries	4
Domestic Fuel and Steam Production	48
Total	100

unit which might be considered a prototype for those to follow was installed at Shamrock Oil & Gas Company, Sunray, Texas, and completed in the spring of 1952.

The Standard Oil Development Company has been studying methods for coking in a fluidized bed. In principle, this is similar to the contact coker except that the particle sizes are in the range where fluidized solids technique can be employed. Operation of a 100-barrel-a-day pilot plant has shown extremely interesting results on a wide variety of stocks. It is presently planned to install fluid coking plants at several refineries within the Jersey family and completion of such plants may reasonably be expected within two or three years.

ECONOMIC INCENTIVES. Many are coking processes available to the refiner with demonstrated commercial feasibility. These processes are discussed in considerable detail later in this Symposium, and include those licensed by Blaw-Knox, The Lummus Company, and M. W. Kellogg Company.

Of paramount interest to the prospective purchaser of a coking process is the net return he can expect on his investment dollar. Each of the commercial processes available emphasizes a specific product distribution. For the purposes of illustration, a sample calculation is shown for the economics of the Blaw-Knox Decarbonizing Process, which aims for minimum coke and maximum distillate production. These economics are summarized in Table 1.

Colquette and Peters, in their paper, "Increase Earnings Through Coking of Residual" (PETROLEUM REFINER, *31*, 160-2, 1952), describe the economics of a typical case wherein delayed coking is installed in conjunction with other facilities. An investment of $5.8 million is shown on the basis that cracking facilities must be provided for the coker gas oil. (Table 2.)

FUTURE MARKET POSSIBILITIES. Of interest to the investor in coking facilities is the future of the market for petroleum coke. Fortunately, the market appears highly diversified and indications are that there is considerable room for increased production. The market stability is enhanced by the fact that there is a wide variety of users. These consumers, and their relative share of the market are shown in Table 3.

A highly interesting possibility is the manufacture of acetylene, which should find particular interest with those refiners engaged in petrochemicals. Economics of a typical acetylene operation, beginning with petroleum coke and limestone as intermediates, are shown in Table 4. The 7.27c per pound cost computed for acetylene made by the calcium carbide-coke route compares very favorably with prices computed for acetylene from other processes and is of particular interest when it is remembered that the operation is proven commercially and is not experimental.

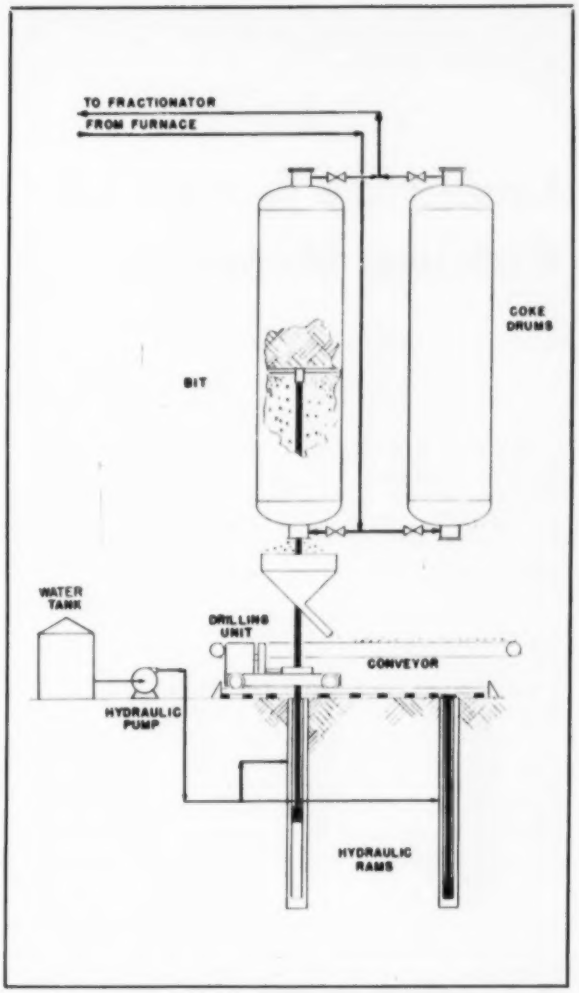


Figure 4. Mechanical decoking system, featuring drilling unit, conveyor, and hydraulic rams.

TABLE 4

Coke Utilization

Acetylene Production from Calcium Carbide

MATERIAL BALANCE	Lbs./Day
Charge:	
Coke	200,000
Limestone	280,000
Products:	
Acetylene	114,000
MANUFACTURING COSTS:	**$/Day**
Raw Materials:	
Coke at $20/Ton	2,000
Limestone at $20/Ton	2,800
Labor (Operating, Maintenance and Supervision)	1,040
Maintenance Material	300
Utilities:	
Power at 0.5¢/KW. Hr.	2,025
Water	40
Chemical	100
Total Operating Costs	$8,305
ECONOMICS:	
Investment	$2,700,000
Cost of Acetylene/Lb.	7.27¢

Fuel Oil Reduction

Lummus Delayed Coking Process

MODERN REFINERIES, particularly those located inland, are concerned more and more with the ability to produce a ratio of distillate oils to residual fuels consistent with market demands. A most effective means for accomplishing this flexibility is by the installation of a modern coking unit, or by increasing the capacity of an existing unit.

THE DEMAND FOR economical and high capacity coking units has presented new design problems. To assure long uninterrupted runs, the delayed coking unit requires proper design of its heater and coke drum, particularly the proper ratio of coke drum diameter to its height.

The amount of coke production governs the volume to be provided in the coke drum for a given time of operation. The conventional delayed coking unit has two drums operating in cycles. One drum is on stream, while the other drum previously filled with coke, is being steamed, cooled, hydraulically decoked, reheated and prepared for the switch.

Until a few years ago due to limitations of decoking methods, refinery technique, and manufacturing facilities, coke drum diameters were limited in size. A large unit required two sets of coke drums and an expensive duplication of piping, switch valves, structures, etc.

To prevent carryover of coke from the coke drum into the fractionating equipment, the vapor velocity in the coke drum should not exceed certain allowable velocities. For a given diameter of two coke drum systems, the allowable velocity controls the reduced crude capacity of the unit. In a recently designed large coking unit, handling 25,000 barrels a day of 21.5 API gravity reduced crudes, it was determined that one set of two 20-foot diameter by 62-foot height coke drums would satisfy the volume requirements for approximately 400 tons a day of coke, but when operating at the usual low drum pressure of 25 psig, the vapor velocity would exceed the allowable. The designer was faced with the alternative of having four coke drums with appropriate diameter to satisfy the allowable velocity requirements, or of operating coke drums at elevated pressure at which the vapor velocities would be within allowable limits.

In order to design this particular unit on the basis of two coke drums, the following possible solutions were analyzed:

1. Increase the operating pressure from 25 to 70 psig. This would keep vapor velocity within the design limit. However, with the higher pressure on the fractionating system, the heavy gas oil fraction, which normally would be withdrawn as a gas oil product, would be retained in the bottom of the tower. This would increase the recycle ratio, heater charge, and would result not only in high vapor velocities in the coke drum but also in production of lower yields and of more refractory gas oil. It would also require costlier equipment.

2. Retain 70 psig on the coke drum, but operate the combination tower at reduced pressure by inserting a pressure reduction valve between the coke drum and the combination tower. This would introduce a very sensitive operating problem possibly resulting in premature coking of the vapor line and shutting down the unit.

3. Provide a vacuum distillation unit after the high pressure combination tower to reduce the charge to the coking unit. The additional cost of such a vacuum unit and of its operation was calculated to be too high for such a purpose.

4. Operate the coke drum and combination tower at intermediate pressures of approximately 40 psig and provide an atmospheric flash drum instead of a vacuum system to lift and remove heavy gas oils. This method would reduce the coke drum charge to a suitable quantity conforming with the design factors of allowable vapor velocities in the coke drum.

After careful evaluation of the process, its mechanical operation, and advantages and disadvantages of each of the above solutions, Alternative No. 4 was accepted to be the best.

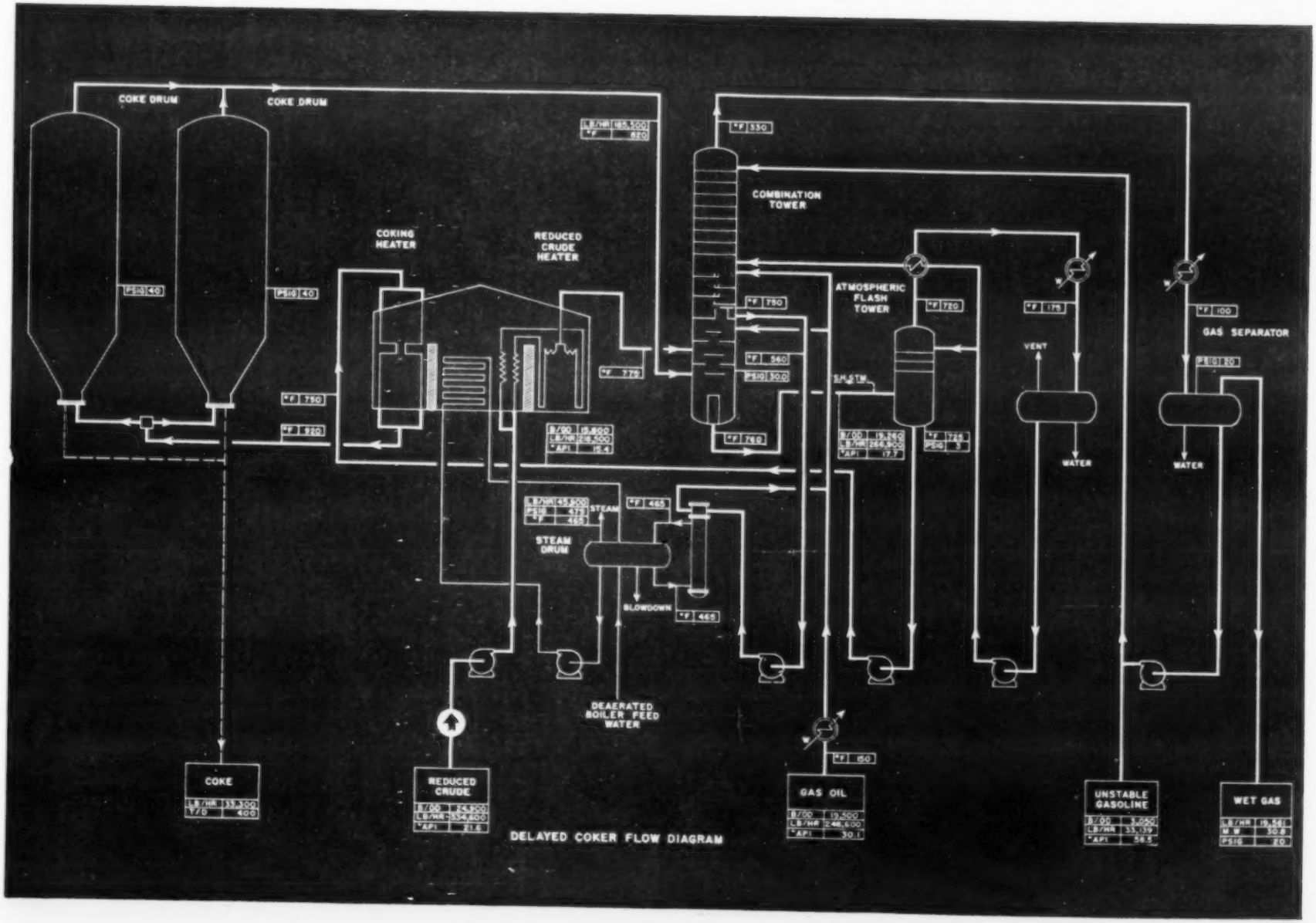
Unless properly designed, a coking heater which handles heavy reduced crude will cause premature cracking, not so much at the outlet where it would be expected, but somewhere in the lower temperature range. In designing a coking heater, the most important factor to be considered is the critical temperature zone at which a particular stock starts cracking and forming incipient coke. If high velocity is provided for this critical zone, coke formation will be kept to a practical minimum and long runs of six to nine months may be normal. Suitable velocities may be maintained either by designing for high liquid velocities or by designing for a suitable range of vaporization in the critical temperature zone. The first method results in high heater pressure drop while the second method controls the vaporization by providing a suitable low pressure drop. The temperature of incipient coke formation is lower for the less refractory paraffinic stocks. In the interest of economy and improved operability the high vaporization, low pressure type heater is preferred.

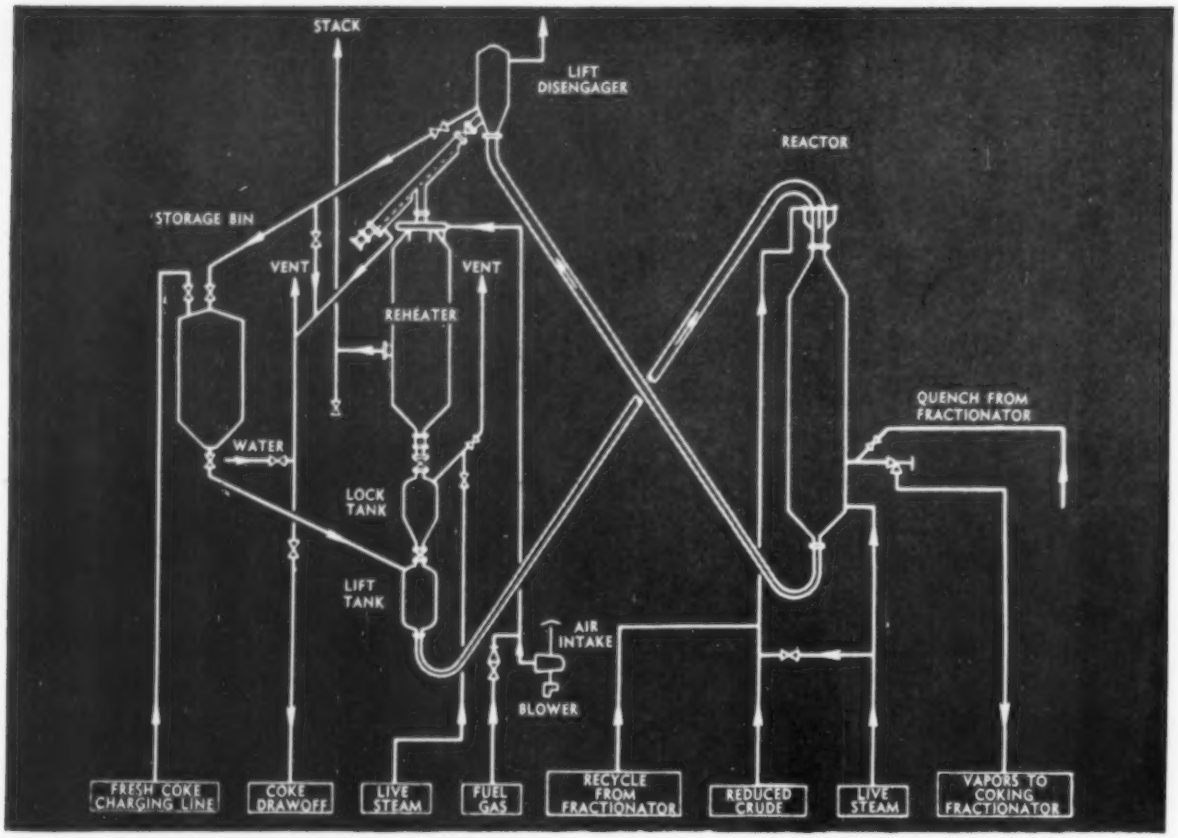
Operating conditions of temperature, pressure, charge and product quantities for a typical unit are indicated on the accompanying flow diagram. Reduced crude is charged through the reduced crude heater to the lower section of the combination tower where it counterflows the vapor effluent from the coke drums. The combination tower bottoms are flashed with superheated steam in the atmospheric flash tower before being charged through the coking heater to the coke drums. The flashed gas oil is returned to the combination tower above the gas oil product pan. The upper section of the combination tower fractionates the gas-gasoline mixture from the gas oil product in the conventional manner.

The coke drums which operate on a 48-hour complete cycle are hydraulically decoked directly into railroad cars which are allowed to drain on a sluice-way. The drained water flows to a settling basin from which clarified water is pumped to a tank for reuse by the hydraulic jet pump.

A large portion of the required reflux heat for the combination tower is recovered by the generation of high pressure steam. This steam is superheated by a coil located in the convection section of the combined coking and reduced crude heater.

Fuel Oil Reduction


COKE DRUM
COKE DRUM
COKING HEATER
REDUCED CRUDE HEATER
COMBINATION TOWER
ATMOSPHERIC FLASH TOWER
VENT
GAS SEPARATOR
WATER
WATER
STEAM
STEAM DRUM
BLOWDOWN
DEAERATED BOILER FEED WATER
COKE
REDUCED CRUDE
GAS OIL
UNSTABLE GASOLINE
WET GAS
DELAYED COKER FLOW DIAGRAM



Lummus Continuous Contact Coking

AFTER MANY YEARS of development, from laboratory bench scale investigations through the pilot plant stage to the present operating commercial unit, it is believed that the continuous coking process provide the best solution for petroleum coking in the immediate future.

The contact coking process possesses degrees of freedom in the areas of time, temperature and pressure impossible to attain by delayed coking methods.

It has been demonstrated that gasoline with a motor octane number in excess of 80 can be produced. Because of its ability to operate at higher temperature levels than is possible with a delayed coker, the probability of successfully converting catalytic cycle stock should be attractive. In addition, the contact coking process places no limitation on the volatility of the charge stock and handles any heavy tar or pitch that can be pumped to the unit.

In the operation of the unit, heated reduced crude is charged to the bottom section of the synthetic tower. Any material boiling in the desired product gas-oil range is directly distilled. The re-reduced crude and recycle from the bottom of this tower is preheated in a conventional oil heater to a temperature of approximately 800 F.

A stream of hot coke, produced in the process, is continuously circulated through the reactor vessel and the reheater. This circulation is maintained by means of a mass flow lift, which transports and elevates the coke as a dense unagitated column. The energy for lifting is provided by high pressure steam. The preheated oil charge is thoroughly contacted with the circulating stream of a preheated coke on which the residual hydrocarbon oil is uniformly distributed. In the oil coke contacting zone, the lighter portions of the feed are vaporized, and the heavier unvaporized oils are retained as a liquid film on the coke particles. The wetted coke particles flow by gravity movement through the reactor as a compact bed. In the reactor, sufficient residence time is allowed to complete the coking and drying reactions. From the bottom of the reactor, the dried coke particles are elevated to the lift disengager from which they flow by gravity into the coke reheater. The reheated coke is discharged by gravity into the lock tank, which forwards it into the high pressure lift tank for recirculation back to the oil-coke contacting zone in the top of the reactor.

As oil is charged to the unit, successive increments of coke are deposited upon the circulating coke, resulting in a gradual increase in particle size and in the system's inventory. The larger particles are drawn off through a classifier as a product coke stream and a constant coke inventory is maintained. This product coke is of low volatile content and high mechanical strength.

Fuel Oil Reduction

Check These Operating Possibilities

Fuel oil production can be reduced by

- Severe thermal reforming
- Deep vacuum flashing
- Fuel oil recracking
- Propane decarbonizing

THIS SYMPOSIUM HAS concerned itself chiefly with the reduction of fuel oil production by the mechanism of coking processes. Residual coking represents a modern process designed specifically for converting fuel oil into more saleable products. There are, however, other measures that can be pursued that will achieve, at least directionally, the same end. The purpose of this brief discussion is to summarize these additional measures, particularly regarding thermal reformer operation, vacuum flashing, and propane deasphalting.

PROPER OPERATION OF THERMAL REFORMERS. Many refiners lack the managerial courage to operate their thermal reformers at the optimum temperature. Some companies are running with coil oil temperatures as low as 800 F. This practice came about through high level pressure to extend run lengths and incur minimum downtimes for coil cleaning. Certainly no one can quibble with this philosophy when fuel oil is selling for $2 per barrel. But when the price is half that, then its another story entirely. Money can well be spent for coil cleaning when the objective of transforming fuel oil into gasoline is being accomplished. As an emergency measure, the coil outlet temperature may well be pushed up into the league of 860 to 880 F., with an improvement in gasoline yield of as much as 5 percent. Thus the first step is a careful check of thermal cracker operations to be certain that severities have been readjusted for the current low price of fuel oil.

CRITICAL RERUN DISTILLATION. A large part of the fuel oil being sold from the smaller refiners may contain as much as 25 percent of recoverable gasoline. The fault here lies with the rerun distillation. Now is the time to be certain that furnaces are being fired at the maximum, reflux condensers are clean, and maximum reflux rates are being used. A final possibility is that surplus tankage can be used to backup feed ahead of the rerun column, thereby making it possible to run at lower feed rates.

IMPROVED VACUUM FLASHING. Many refiners are equipped with vacuum flashing equipment as a part of their crude distillation unit. Minimum residuum yields (with resulting minimum fuel oil production) can be obtained by running this equipment at maximum coil outlet temperatures and minimum tower pressure. Coil outlet temperatures can frequently be pushed up as high as 770 F. with proper control. This will result in increased thermal cracking unless steam jet equipment is in top shape and cooling water for reflux condensers and barometric condenser is as low as possible. Now is the time to be certain that steam jet equipment is clean and operating properly. If real trouble is being experienced with pressure, an additional jet can be added at a very moderate cost and often with exceptionally fast payouts. The temperature of the cooling water is highly critical and a quick check of the cooling tower may show where spray headers can be cleaned or distribution improved in other ways. If cooling water cannot be reduced below about 130 F., it will be profitable to use once-through water on the jets, assuming that an adequate supply is available.

JUSTIFIABLE RECRACKING. Most small refiners have an inherent distrust of recracking even though their kinsmen in the larger refineries are doing it daily. Obviously the yield is poor, but again the market situation of fuel oil now warrants the taking of measures that were formerly uneconomical. Inland refineries, particularly, can justify recracking of fuel oil, since they are now having difficulty locating fuel oil markets regardless of price. A general rule of thumb is that when the price of fuel oil is below $1 per barrel, recracking is justified. Coil temperatures should be pushed to the maximum to assure that the maximum benefit is derived from this operation.

PROPANE DECARBONIZING. This modern process is particularly suited to the refiner who has excess catalytic cracking capacity. Briefly, it makes possible, recovery of additional cracking unit feed stock from fuel oil.

The process is a liquid-to-liquid extraction system employing propane as a solvent. Asphalt, color bodies and other undesirable constituents are separated from reduced crude.

Here is a brief description of the process flow. Reduced crude is pumped from storage through a steam heater to the deasphalting tower where it contacts countercurrently the propane solution entering the lower part of the tower. The deasphalted oil withdrawn overhead flows to a low-pressure evaporator where a large portion of the propane is flashed off. The remaining propane is flashed off in a high pressure evaporator and steam stripper. The deasphalted oil is then ready for storage and eventual cracking.

Many commercial units, both foreign and domestic, are now in operation. The M. W. Kellogg Company licenses the process.

Fuel Oil Reduction

The Blaw-Knox Decarbonizing Process

THERE ARE SEVERAL new coking processes which show certain promising elements of applicability to modern refinery situations. However some of these processes may have elements of either high cost, non-flexibility, or commercial non-availability. The Blaw-Knox Company felt that the solution to the immediate problem could best be realized by offering industry a process which combined known chemical and physical principles with proven practices in the fields of coking and coke-handling.

Based on the thesis that the refiner makes money from gasoline, the specifications for such a process are that it makes minimum coke and maximum coker distillate for subsequent catalytic cracking; and that coke handling equipment be of least complexity and lowest cost.

Laboratory, pilot plant, and commercial operations have established that preflashing and low pressure delayed coking produces minimum coke yields, and maximum yields of virgin and coker distillate. Proven means for mechanical decoking are available in the Hughes decoking equipment, as improved and currently offered by the Forsyth Engineering Company of Houston. These elements—preflashing, delayed coking under special conditions to minimize gas production and maximize coker distillate production, and simple, proven, mechanical decoking equipment—are combined in a compact process and mechanical arrangement which is offered to industry to meet the present fuel oil problem. Since this is basically a feed preparation system for catalytic cracking, running to coke, it is called "Decarbonizing" to distinguish it from conventional coking processes.

PROCESS DESCRIPTION. This unit is designed to process a reduced crude and produce a clean (low Conradson Carbon) catalytic cracking feed stock. A byproduct of the process is a high grade petroleum coke, useful as a raw material in certain chemical industries. A process flow diagram for the coking operation is shown on the opposite page.

Referring to the diagram, the hot reduced crude is pumped into the base of the fractionator. A portion of the fresh feed is flashed in the base of the fractionator by the addition of stripping steam and the heat supplied by the coke drum effluent.

The fractionator bottoms stream is pumped through a furnace where it is heated to approximately 930 F. The heating curve is such as to minimize cracking in the tubes. From the furnace the charge flows to one of the two coke drums. One is in coking operation while the other is being decoked. The mixture of vapor and liquid enters the bottom of the coke drum and vapor leaves the top. The liquid remains in the coke drum and, under the time-temperature conditions which prevail, is converted to coke.

The vapors from the coke drum flow to the base of the fractionator where their heat is used to vaporize a portion of the fresh feed. The coke drum and fractionator are operated at approximately 7 psig and the reflux tank is operated at essentially atmospheric pressure. This insures maximum vaporization of the fresh feed and minimum charge to the coke drums.

In the fractionator, a gas oil product is condensed and drawn off of a well-type tray. The stripping steam, gas and gasoline are taken overhead and cooled to approximately 110 F. to condense the gasoline product plus the necessary reflux. The vapors from the reflux tank are then compressed and delivered to the battery limits for processing in a vapor recovery plant.

The fractionator has a side reflux. A gas oil is taken off of a well-type tray and pumped through a waste heat exchanger. The gas oil is cooled from approximately 500 F. to approximately 400 F. and heat is removed by the generation of 150 psig steam. The gas oil from the waste heat exchanger is split. A portion is returned to the fractionator as side reflux and the net gas oil product flows through a cooler where it is cooled to 150 F. and is then sent to storage.

DECOKING OPERATION. Two coke chambers were provided to operate on 24-hour cycles. One drum will be on process for 24 hours after which it is switched, and 24 hours will be available for decoking. The actual time for decoking and preparing the drum for process is 13.5 hours with a balance of 10.5 hours spare time. The coke drums have been sized for 24-hour cycles so that only one decoking crew will be required each day.

Approximately four hours before the decoking crew is scheduled for decoking, the drums are switched. The coke drum taken off stream is then steamed for one-half hour. A portion of the stripping steam to the fractionator is cut through a full coke drum and the steam and oil vapors passed first to the fractionator and then to blowdown. After steaming, the coke is cooled with water. Water is added to the bottom of the drum, and the steam formed is vented to blowdown stack. The water cooling operation will require approximately three hours. After cooling the drum, the water is drained and the drum is ready for the decoking crew.

The decoking crew unheads the coke drum and positions the drilling engine. The coke is then drilled out. As coke falls out the bottom of the coke drum it is funneled on to a conveyor belt and is carried to the coke pile or directly to railroad cars. The coke drill is run by a steam engine and is lifted by a hydraulic mechanism. After the coke has been drilled out of the drum, the decoking crew heads up the drum. The decoking crew has an estimated two hours' spare time.

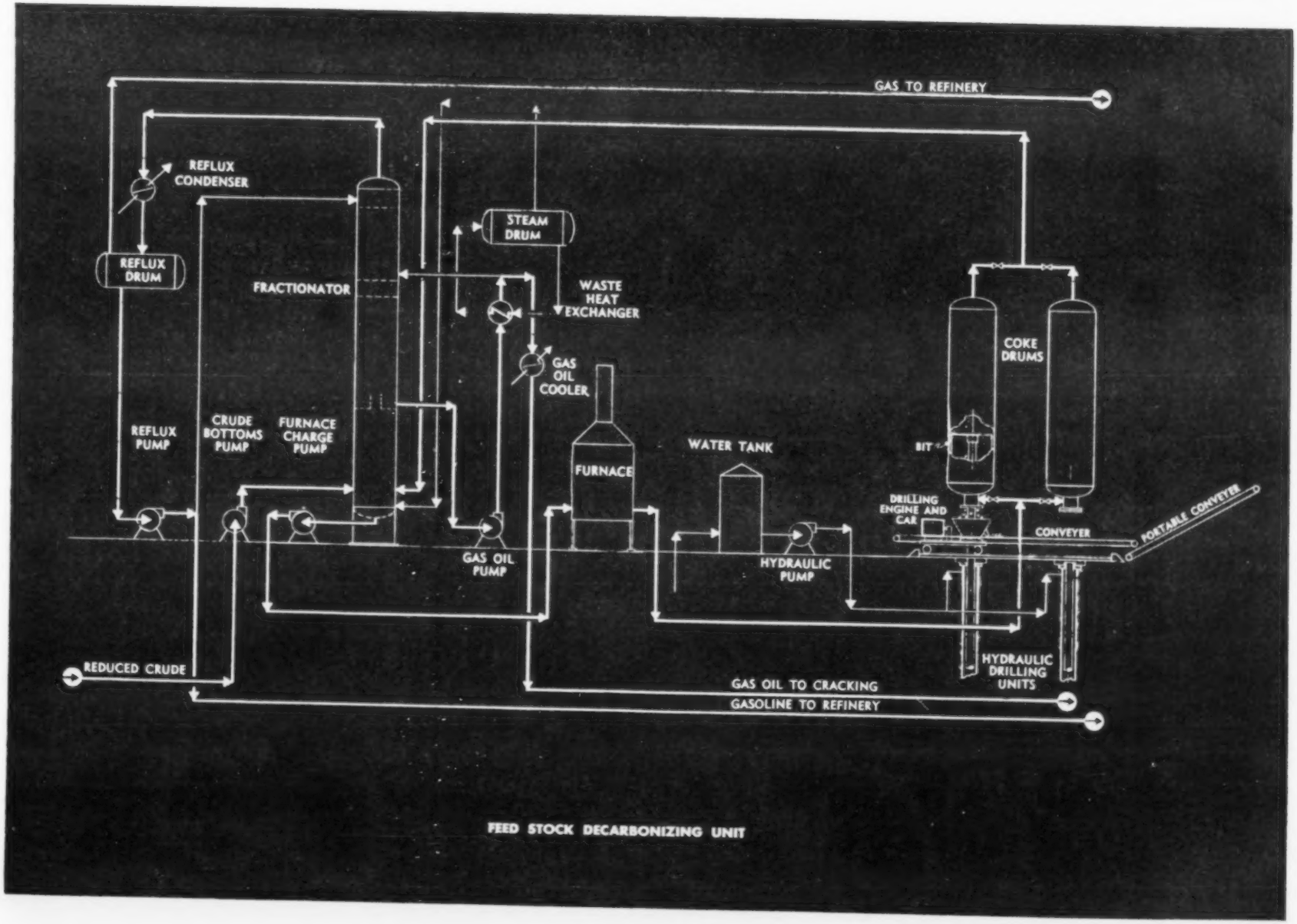
When the decoking crew has completed its work the vessel is ready for the heating and switching operation. The coke drum is heated up with hot oil vapors before being placed on stream. The vessel is now ready for the coking operation.

TABLE 1

Blaw-Knox Decarbonizing Unit
Typical Yields for Light and Heavy Residuum

CHARGE	East Texas	Mid Continent
Reduced Crude	10,000 B/D	10,000 B/D
Reduced Crude Inspections		
Gravity, °API	26.0	14.4
Carbon Residue	3.98	12.2
Yields		
Gas	825 MSCF/D	2,750 MSCF/D
Gasoline	563 B/D	1,300 B/D
Gas Oil	9,060 B/D	7,040 B/D
Coke	79 T/D	280 T/D

Fuel Oil Reduction



FEED STOCK DECARBONIZING UNIT

The Kellogg Delayed Coking Process

IN VIEW OF the continually diminishing market for residuals since World War II, the disposal of these products has been a growing problem which today is literally forcing a number of refiners to install processes which are directed at reducing the amount of fuel oil produced.

Consequently refiners both here and abroad are revaluating—and in several instances already installing—delayed coking with its two-fold economic advantage of producing high yields of clean catalytic cracker feedstock and a residual product of coke instead of fuel oil.

DELAYED COKING. Although only a by-product of the process, the coke produced is of exceptional purity and density, therefore attracting a premium price for use in the manufacture of carbon electrodes employed in the aluminum and other electro-metallurgical industries. It is also a superior fuel for which it is possible to develop markets in almost all localities. Used by many refiners in their own power plants, the product has other uses with large public utilities. Additional profitable outlets are the cement industry, where it is used for firing kilns, the tobacco industry, where it is employed for drying purposes and as a domestic fuel. The coke is hard, low in volatile matter, has a negligible ash content, and its heating value averages over 16,000 Btu. per pound.

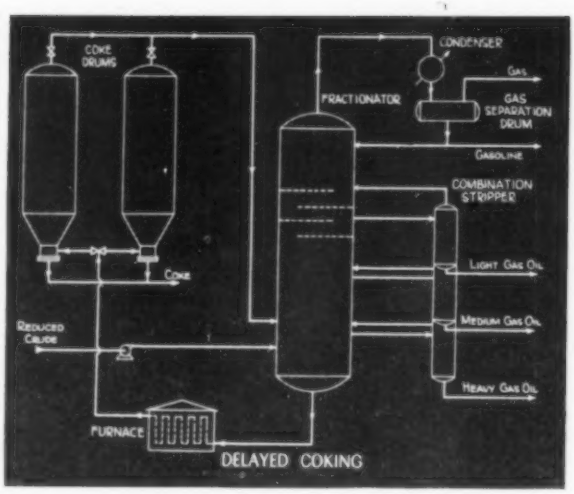
ITS FEATURES. Delayed Coking differs from other coking procedures in that a topped crude is quickly heated to a high temperature in a pipe still and then introduced into an insulated drum to coke by its contained heat. The result is a controlled crack per pass—usually 10 to 20 percent—currently resulting in:

- Greater cleanliness of cat cracking feed as compared with vis breaking.
- Maximum quality of cat cracking feed per barrel of crude.
- Minimum over-all coke production per barrel of ultimate gasoline.

Economy of fuel consumption and low operating and maintenance costs are ensured by the following features:

- Low coke drum pressure—16 to 60 pounds.
- No extra heat required for the coke drums.
- Hydraulic cleaning methods.
- High stream efficiency.
- Simplicity of operating (essentially a pipe still with coking drums added).

Fuel Oil Reduction



- Excess heat evolved in the process may be used for steam generation.

HOW IT WORKS. Reduced crude from the topping unit is charged to the base of the Delayed Coker fractionator where the light ends are flashed off. The reduced crude plus recycle is removed as bottoms and charged to the furnace where it is quickly heated to a high temperature and discharged into an insulated drum held at 10 to 60 pounds pressure. Here it cokes by contained heat.

For a typical charge, approximately 12 percent by weight of the reduced crude goes to coke, 4 percent to gas and the remainder to light liquid products.

A specially designed transfer manifold makes it possible to feed any of the coke drums without leaving "dead space" in the line where the hot charge might lie stagnant and coke. In the modern installation, enough drums, which are filled in rotation, are furnished to allow a continuous operation. The actual number of drums required is determined by the feed rate and carbon-forming characteristics of the reduced crude. The vapors from the drums are fractionated in a bubble-tower, taking gas and gasoline overhead and withdrawing gas oil (cat cracker feed) as a side stream. Heavy ends from the fractionator are recycled back through the furnace in admixture with the fresh feed.

When a filled coke drum is to be switched from the system, the empty drum to be cut into the circuit is first preheated by passing through the hot vapors from the drum in service in gradually increasing volume. When the proper temperature is reached, the hot charge from the furnace is cut out of the drum in service and cut into

the preheated drum. The filled coke drum is steamed through thoroughly to remove all vapors, and then water is admitted to cool the coke sufficiently to allow its removal safely without any danger of flash.

Important to the unit's efficiency is the hydraulic method of cutting coke from the drums. The method, devised by Shell Oil Company, has been developed by Worthington Pump & Machinery Corporation. High impact-producing water jets bore a hole downward through the coke bed, and then hydraulic cutting nozzles remove the coke which falls with the water from the chamber.

Aside from the savings in cost and time, the hydraulic method of coke removal has the further advantages of preparing, free from contamination, high-grade, marketable lump coke; maintaining a clean coking drum and thus ensuring maximum capacity; and reducing to low levels the health and accident hazards so prevalent in other methods of coke removal.

A VARIATION. Among the variations in design of coking units is the combination Crude Flashing and Delayed Coking unit. A simplified diagram is shown in Figure 1. For refiners who are increasing crude capacity and are so set up that a mixture of coker and straight-run gasoline is not objectionable, this unit permits major savings.

One tower is dispensed with because the topping of the crude and fractionating of the coker products are done in the same bubble tower. Intermediate tankage, which is required when topping is accomplished separately, is eliminated. The number of heat exchangers is reduced appreciably, and naturally other savings are gained in reduced piping and auxiliary equipment such as pumps.

As seen from the diagram, the crude enters the furnace where it is heated to the desired temperature and thence to the base of the bubble tower where it is flashed. The reduced crude comes off as bottoms and returns to the furnace. From this point on, the normal coking operation proceeds.

DEVELOPMENT. The concept of Delayed Coking originated with the Standard Oil Company of Indiana in the late Twenties and was developed into commercial production by that company, which built the first commercial unit in 1931. Since that time The M. W. Kellogg Company has given special attention to the furnace, which is the most important part of a coking unit. Poor furnace engineering can mean cokers which have excessive downtime with resultant low stream efficiency. Broadly speaking, the design of the furnace must provide for rapid heating and speedy movement of the feed lest it coke excessively in the furnace tubes and quickly halt the operation.

Although the on-stream efficiency of Kellogg units has been excellent over the years, today's more modern furnaces have extremely long life and long on-stream runs. Recent runs on Kellogg units have been six to eight months. Inspection of furnace tubes at the end of these periods has indicated that appreciably longer runs are possible.

One of the chief features of the Delayed Coking Process is its flexibility. The end point of the heaviest liquid product may be varied widely to cover the range from so-called light to heavy gas oil.

Continuing pilot plant work combined with thousands of commercial operating hours on the units already installed provide a wealth of information for the design of Delayed Cokers. A new processing technique that Kellogg has developed in recent years, permits the Delayed Coking of pitch recovered from existing vacuum units. Other developments indicate the ability to design for practically any variable and to obtain a product distribution to meet any refiner's requirements. For example, the following product variations are possible on a typical Mid-continent 30 percent reduced crude:

- Gas Oil End Point—can be varied from 700 to 900 F.
- Coke Yield—can be varied by 55 percent of the normal coke yield.
- Coke VCM—can be varied from 7 to 11 percent.
- Gas Oil Yield—can be varied by 25 percent of the normal gas oil yield.

CONCLUSION. The brief review and appraisal of the effect that recent engineering improvements have had on an established process indicate that Delayed Coking in its current version has a definite place in the modern refinery.

Every refiner can well afford to reexamine his operation with the view toward incorporating a Delayed Coking unit therein, capitalizing on its five basic advantages:

- Efficiency in increasing the volume of feed stocks for cat cracking facilities.
- Economy of installation and operation as a feed stock preparation unit.
- Reduction of residual fuel oil to a minimum.
- Flexibility to adjust to a wide variation of product distribution.
- Production of premium by-product coke for use in chemical and other industries.

Indicated in the economic evaluation below is the economic evaluation of delayed coking and vacuum flashing, the most conventional feed prepster to a typical refining sequence including recycle fluid catalytic cracking, thermal reforming of naphtha, cat poly, and alkylation. Feed was established at 40,000 barrels a day of 38.6° API paraffinic crude, topped to 32.5 percent bottoms, plus 4000 barrels a day of 26-pound casinghead.

Yields, Volume Percent on Crude

	Vacuum Distillation	Delayed Coking
Premium Gasoline—93 CFR-R	13.2	14.0
Regular Gasoline—86 CFR-R	54.1	56.1
Total Gasoline	67.3	70.1
Kerosine	12.0	12.0
Furnace Oil	11.4	10.7
Fuel Oil	10.1	3.0
Gas (Fuel Oil Equivalent)	8.3	11.0
Coke (Recoverable)	....	5.4

Assumed Price Structure

	Gulf Coast Unit Price	East Coast Unit Price
Premium Gasoline—93 CFR-R, per gallon	$ 0.1225	$ 0.1385
Regular Gasoline—86 CFR-R, per Gallon	0.1125	0.1285
Kerosine, per Gallon	0.0925	0.1075
Furnace Oil, per Gallon	0.080625	0.0975
Fuel Oil, per barrel	1.63	2.10
Gas (Fuel Oil Equivalent), per barrel	0.66	2.10
Coke (recoverable), per ton	10.00	10.00

Economic Comparisons

	Delayed Coking
Incremental Credits over Vacuum Distillation per Year:	
East Coast	$1,207,000
Gulf Coast	1,153,000
Incremental Investments in Processing Equipment East or Gulf Coast	1,400,000

Fuel Oil Reduction

Understanding the Chemistry of

. . . PETROCHEMICAL Reactions

II. Non-Hydrocarbon Constituents of Petroleum. Sulfur and Nitrogen Compounds.

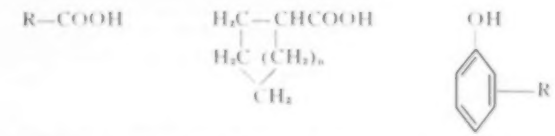
III. Non-Hydrocarbon Constituents of Petroleum. Oxygen Compounds.

IV. Oxidation of Hydrocarbons.

Lewis F. Hatch, University of Texas, Austin

THE OXYGEN compounds in petroleum have been extensively investigated because of their ease of extraction and their actual and potential utilization by the chemical industry. They occur in both crude oil and its distillates from which, due to their acidic nature, they may be quite easily separated and characterized. As a result, more oxygen compounds have been identified than sulfur and nitrogen compounds combined.

The three types of oxygen compounds listed below have been studied more fully than any others.



Aliphatic acids — Naphthenic acids — Phenols (Cresylic acids)

These acidic compounds may be extracted by aqueous or alcoholic sodium hydroxide from either the crude oil or from its distillates. The latter source is more frequently used due to the increased concentration of the desired compounds in certain fractions. There is much uncertainty regarding the relative amounts of acids in crude oil and in the refinery products from an equal volume of crude oil, but there is no essential difference in the nature of the oxygen compounds obtained from either source.

The aliphatic and naphthenic acids are fractionated by distillation of the free acid or their methyl or ethyl esters. Esterification effects a separation from the phenols which, though acidic, will not esterify. Phenols may also be separated from the carboxylic acids (R-COOH) by proper selection of extraction medium. Fractional distillation alone seldom gives individual compounds in high yield, and other physical methods must be used. Fractional neutralization or liberation is the most commonly used method to effect this further separation. Modern countercurrent extraction equipment makes these methods particularly efficient. Distribution between solvents and surface active effects are also used to supplement distillation. These methods do not primarily depend on boiling points or molecular weight.

Aliphatic Acids

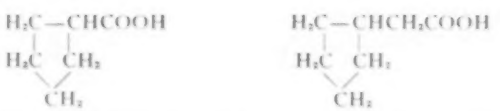
The aliphatic acids in petroleum have not been as extensively studied as the naphthenic acids and the phenols (cresylic acids), for they are not present in quantities which would lead to their commercial utilization. The work that has been done, however, shows that all the acids through C_9 are present, and there is no indication that the higher molecular weight ones are not also present. Both palmitic ($CH_3(CH_2)_{14}COOH$) and stearic ($CH_3(CH_2)_{16}COOH$) acids have been found. Table 1 gives the distribution of the aliphatic acids in a Venezuelan thermally cracked naphtha (100 to 400 F.). These acids were extracted by aqueous caustic.

TABLE 1
Aliphatic Acids Extracted from Venezuelan Thermally Cracked Naphtha
(100 to 400 F.)

ACID	Formula	Weight, Percent
Acetic	CH_3COOH	21.8
Propionic	CH_3CH_2COOH	35.8
Butyric	$CH_3(CH_2)_2COOH$	8.7
Valeric	$CH_3(CH_2)_3COOH$	9.0
Caproic	$CH_3(CH_2)_4COOH$	9.7
Higher Acids		15.0

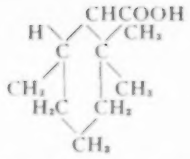
Naphthenic Acids

Naphthenic acids may exist with many different structures, but those in petroleum fractions are mainly the derivatives of cyclopentane, with the carboxyl group either attached directly to the ring or separated by one carbon atom.

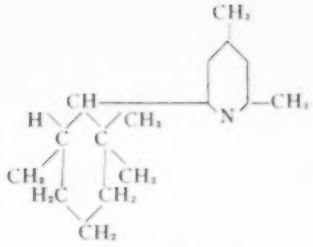


Cyclopentanecarboxylic acid — Cyclopentylacetic acid

Cyclohexyl derivatives are found to a lesser extent. There may be one or more methyl groups on the cyclopentyl ring. For example, both *cis-* and *trans-* 2,2,6-trimethylcyclohexanecarboxylic acids and 2,3-dimethylcyclopentylacetic acid have been isolated, among other similar ones. The presence of the trimethylhexanecarboxylic acid is of appreciable interest, because the closely related base, 2,4-dimethyl-6-(2,2,6-trimethylcyclohexyl)pyridine, is also found in petroleum.



2,2,6-Trimethylcyclohexane-carboxylic acid



2,4-Dimethyl-6-(2,2,6-trimethylcyclohexane) pyridine

The similarity between these two compounds indicate the close relationship which may exist between the naphthenic acids and the nitrogen bases in petroleum. This similarity denotes a common origin and may be a clue to the origin of petroleum.

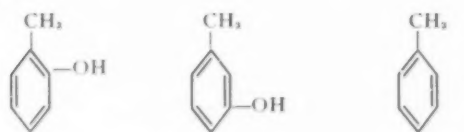
Most of the investigation of these naphthenic acids is being done at The University of Texas under the direction of H. L. Lochte.

Bicyclic acids occur in the range of C_{13} to C_{15} with some as low as C_{10} and C_{11}. The nature of these bicyclic acids is still a mystery. There is a very low concentration of aromatic acids in petroleum. Some of the polycyclic acids seem to have mixed aromatic and naphthenic rings.

The naphthenic acids of commerce are a mixture having a molecular weight range of 180 to 350. They are dark in color and have an unpleasant odor. They are principally used in the form of their metal salts. The lead, cobalt, and manganese salts are used as paint driers, and lead naphthenates are also components of extreme pressure lubricants. Other salts are used in greases and to jelly gasoline. Copper naphthenates are used as wood preservatives and in various paints.

Phenols

Phenols occur to an appreciable extent in crude oil and in the appropriate fractions of refinery products. The commercial mixtures of phenolic materials are called *cresylic acids* from a predominance of the following cresols.



ortho-Cresol *meta*-Cresol *para*-Cresol

although in selected mixtures they may be present in only minor amounts or completely absent.

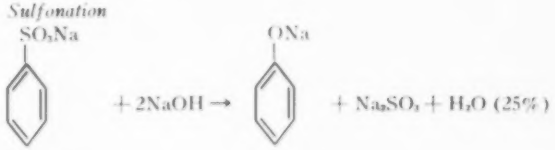
The naphthas contain cresols, xylenols ($C_6H_3(CH_3)_2OH$) and phenol, in that order, along with smaller amounts of higher molecular weight phenols. A cracked naphtha (300 to 450 F.) has been reported to give cresylic acid of the following composition: cresols 45 percent; xylenols 25 percent; phenols 20 percent and 10 percent impurities. The lighter naphthas are richer in phenol, while the heavy naphthas are richer in cresols. The distribution of phenols in petroleum is similar to that in coal tar.

2,3,6-Trimethylphenol is obtained from petroleum and is used in the synthesis of the antisterility vitamin E. It would appear that the petroleum industry rivals a well-known tonic in having a baby in every oil well.

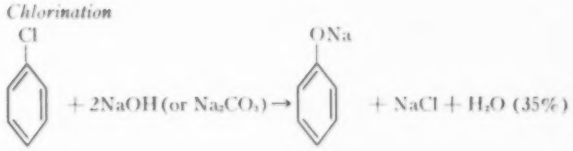
Three separate operations are required to recover cresylic acids from petroleum naphthas. The first step is the extraction by caustic, followed by recovery of the cresylic acids by acidification of the alkaline aqueous phase. The third step is the removal of impurities or contaminants, sulfur, neutral oil and aliphatic acids being the three major ones encountered. Neutral oil is not a serious problem if dilute caustic or soda washing is used. Cracked naphthas are relatively free of aliphatic acids, but some thermal naphthas may have as much as two-thirds of the extracted acids as aliphatic acids. The aliphatic acids and phenols can be separated by appropriate extra active processes. The presence of sulfur compounds is the most serious problem. The sulfur compounds may be removed or reduced in quantity by air blowing the caustic before liberating the cresylic acids, by neutralizing the caustic at a pH of 9.7 to 10, or by distillation and segregating a heart cut. The sulfur concentrates in the lower and higher boiling fractions.

Acid treatment of naphtha fractions may destroy or remove from one-third to two-thirds of the phenols originally present. This is a problem which must be considered when estimates are made regarding petroleum's position in supplying the increasing demand for phenols. These phenols are used in resins, plastics, plasticizers, adhesives, coatings, flotation agents, and for many other applications. The increasing demand will be met from both petroleum sources and by synthetic processes. Petroleum will probably not be a direct important source of phenol, but indirectly it furnishes benzene for the synthesis of phenol by the sulfonation, chlorination and Raschig processes. The figures in parenthesis indicate the percentage of total phenol production contributed by the particular method of synthesis.

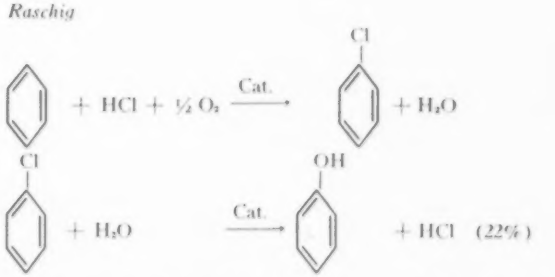
Sulfonation



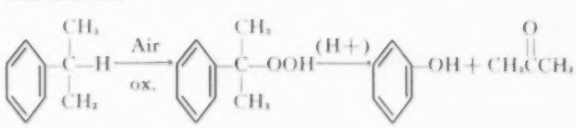
Chlorination



Raschig



Petroleum also furnishes both benzene and propylene for the production of cumene which is oxidized to phenol and acetone.



Cumene hydroperoxide

The cresols are synthesized on a much smaller scale than phenol and come primarily from coal tar.

Solve for Vessel Thickness Graphically

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Carbide and Carbon Chemicals Company
Texas City, Texas

A FREQUENT calculation made by the pressure vessel designer is that in solving for shell and head thicknesses for vessels under internal pressure. For nozzle reinforcement calculations, new designs, or pressure revisions to existing vessels, these calculations must be made. The accompanying graph is presented as an aid in these calculations. It can easily be used for estimating purposes, for a quick check on shells or heads, or to see the effect the change of one variable has upon the others.

Basically, this graph is a plot of the equation for the allowable internal pressure of cylindrical shells as given in Par. UG-27(c), Section VIII, 1950 ASME Code.

$$\text{in which } t = \frac{PR}{SE - .6P}$$

where

P = Maximum allowable working pressure, psi,
S = Maximum allowable working stress, psi,
E = Efficiency of longitudinal joints, or of ligaments between openings, as a decimal,
R = Inside radius of shell, in.,
t = Minimum shell thickness, in.

In addition to the variables, a correction factor curve, "C," appears on the graph to correct the thickness for the ".6P" term in the denominator. Similarly, other "C" curves are shown for the shell outside diameter and head equations.

An example will readily show the use of the chart. A usual problem is as follows: Find the thickness of a cylindrical shell to resist an internal pressure of 1300 psi, constructed of steel whose allowable working stress is 13,750 psi. A weld joint efficiency of 90 percent and an inside diameter of 48 inches is required. The five required steps are as follows:

(1) Enter at 1300 psi on the pressure scale and move horizontally to the stress curve of 13,750 psi.
(2) From this intersection move vertically to the joint efficiency value of 90 percent.
(3) From this intersection move horizontally to the "C" curve for inside diameter of shells.
(4) From this intersection move vertically to the diameter value of 48 inches or a radius of 24 inches.
(5) Finally move horizontally from this intersection to the thickness scale, which indicates a minimum shell thickness of 2.75 inches is required.

In short, move from P to S to E to C to R to t_m, always perpendicular to the preceding direction.

A slide rule solution of the equation shows

$$t = \frac{PR}{SE - .6P} = \frac{1300(24)}{13{,}750(0.9) - .6(1300)} = 2.69 \text{ in.}$$

This shows an error in thickness of 0.060 inch, or 2.23 percent when the chart is used.

The thickness found for pipe must be corrected for the manufacturing tolerance and corrosion allowance as required by Paragraph 122, *ASA Code for Pressure Piping*, 1950 Edition. Head thicknesses, too, must be corrected for the shape of the head by an appropriate multiplying factor as given on the chart.

For example, find the minimum thickness of a seamless torispherical head to resist an internal pressure of 500 psi, if the inside crown radius is 60 inches, the maximum allowable working stress is 13,750 psi, and M = 1.54. The following values should be used in applying the chart:

P = 500 psi, S = 13,750 psi, E = 100 percent, "C" — use head i.d. curve, R = L = 60 in., then $t_o = 2.20$ in., and $t_m = \frac{t_o \times M}{2} = \frac{2.20(1.54)}{2} = 1.694$ in. As a check (Par. UA — 4(d)): $t = \frac{PLM}{2SE - .2P} = \frac{500(60)(1.54)}{2(13.750)(1.0) - .2(500)} = 1.685$ inches, or a chart solution indicates 0.009 inch difference in thickness.

Notice where the efficiency curves discontinue at the bottom of the graph. This line is a plot of the equation $SE/P = 2.6$ ($P \leq .385SE$; $SE/P \geq 1/.385 \geq 2.6$, Par. UG-27(d)) which is the code limit of the cylindrical shell equation. Values below this limit indicate that the thickness must be solved for from the equation for thick cylindrical shells.

If the nature of the work is such that only a portion of the chart is needed, that portion can easily be constructed to a larger scale thereby increasing the accuracy.

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ASME Boiler Construction Code, Section VIII, 1950 Edition, Published by the American Society of Mechanical Engineers.

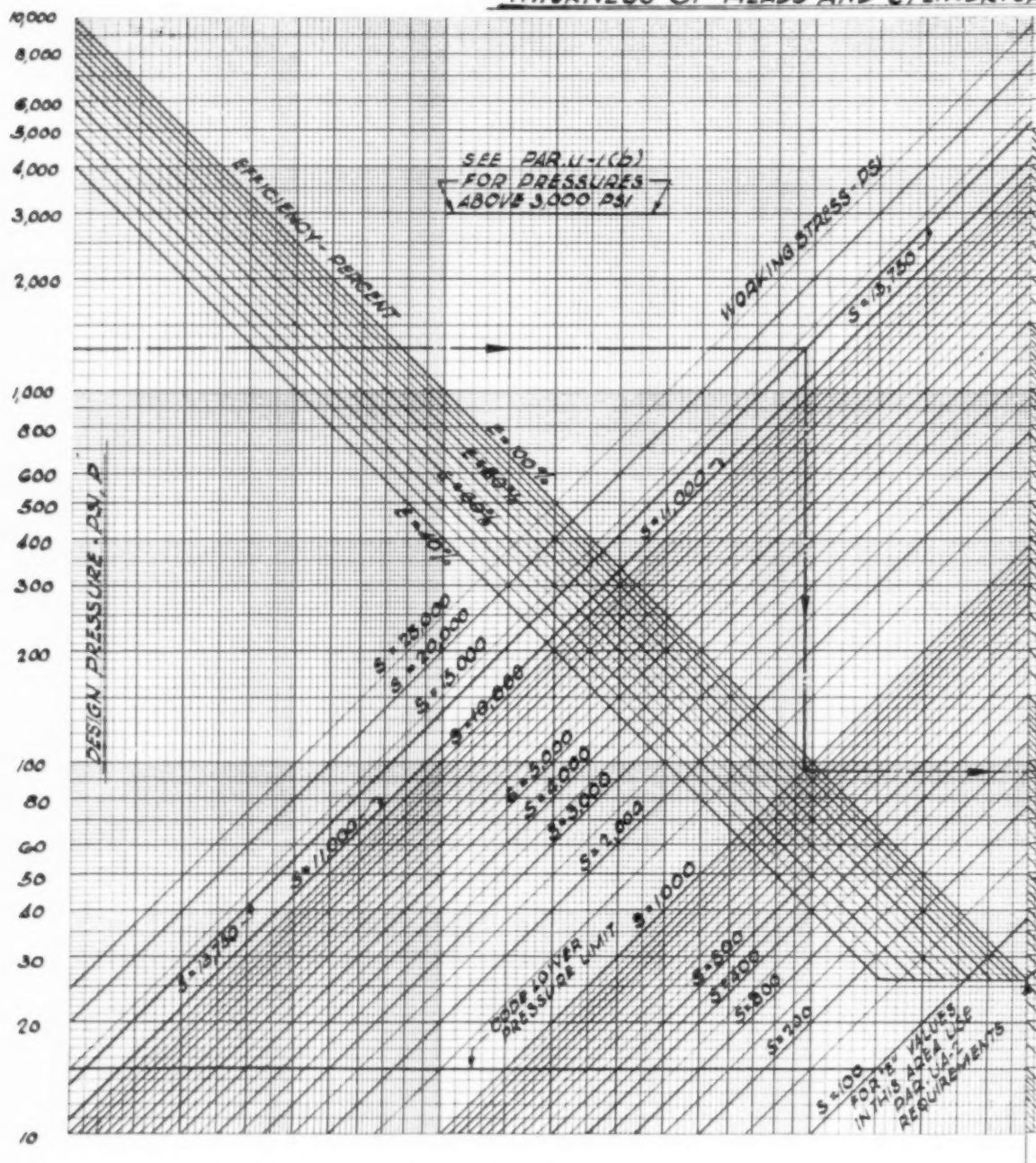
American Standard Code for Pressure Piping (ASA B31.1-1951), Published by the American Society of Mechanical Engineers.

Definitions of Terms Shown on the Chart

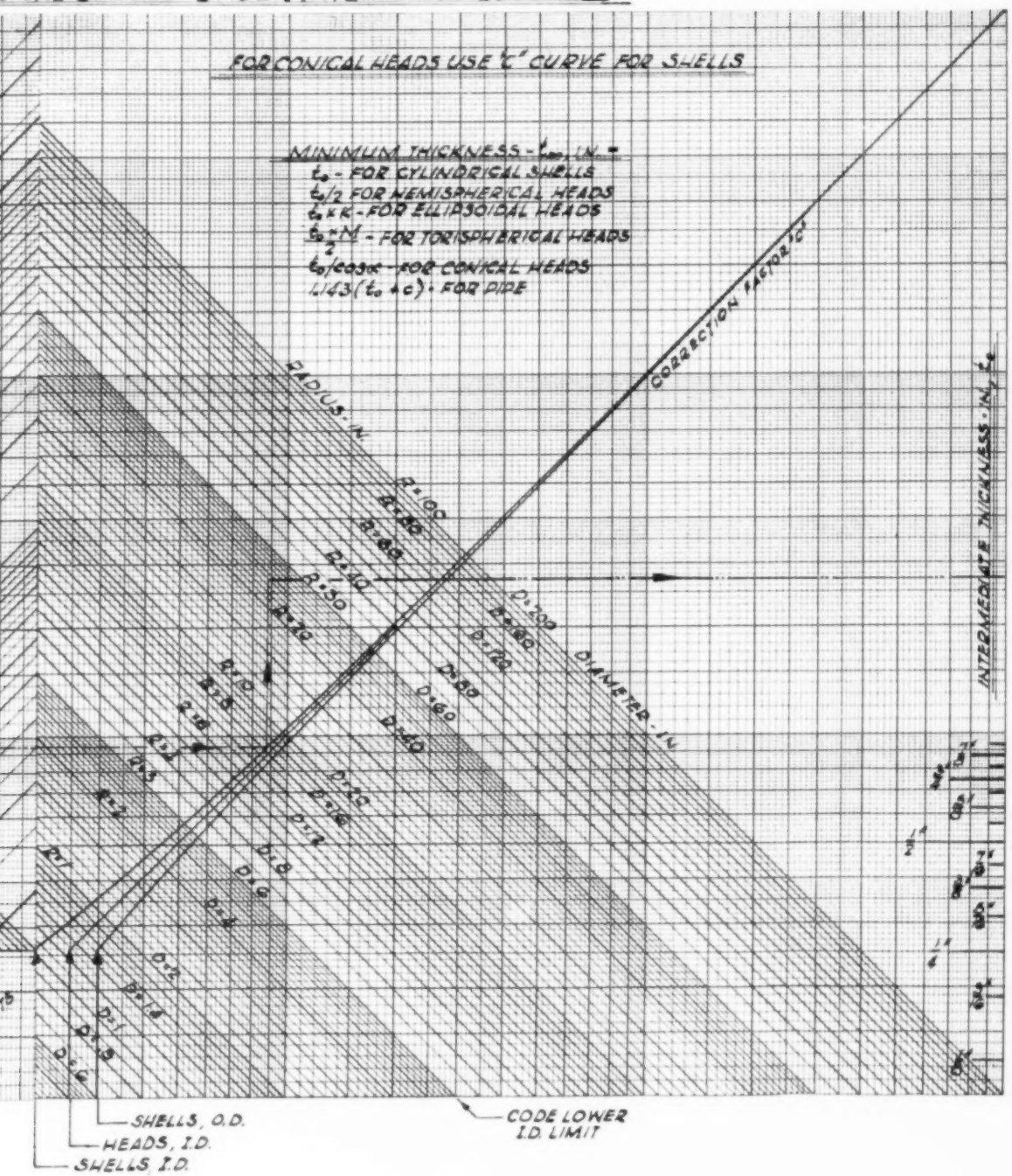
See insert opposite

P = Design or maximum allowable working pressure, psi. All pressures referred to are gage pressures,
S = Maximum allowable working stress, psi,
E = Efficiency of longitudinal joints, or of ligaments between openings, percent,
R = Radius of shell or inside radius of heads, in. (Use correct "C" curve),
D = Diameter of shell or inside diameter of heads, in. (Use correct "C" curve),
L = Inside crown radius of torispherical heads, in.,
α = One half of the included (apex) angle of a cone at the centerline of the head, degrees,
h = One half of the length of the minor axis of an ellipsoidal head, in.,
r = Inside knuckle radius, in.,
$K = 1/6\ (2 + (D/2h)^2)$,
$M = 1/4\ (3 + \sqrt{L/r})$,
c = Allowance for threading, mechanical strength, and/or corrosion, in. See Par. 122(b), *American Standard Code for Pressure Piping*, (ASA B31.1—1951),
t_o = Intermediate thickness, in.,
t_m = Minimum shell or head thickness, in.,
C = Correction factor.

THICKNESS OF HEADS AND CYLINDRICA



RICAL SHELLS UNDER INTERNAL PRESSURE


FOR CONICAL HEADS USE "C" CURVE FOR SHELLS
MINIMUM THICKNESS - t_m, IN. =
t_o - FOR CYLINDRICAL SHELLS
$t_o/2$ FOR HEMISPHERICAL HEADS
t_o x K - FOR ELLIPSOIDAL HEADS
$t_o = \frac{M}{2}$ - FOR TORISPHERICAL HEADS
$t_o/\cos\alpha$ - FOR CONICAL HEADS
1.143 (t_o + c) - FOR PIPE
CORRECTION FACTOR, C
INTERMEDIATE THICKNESS - IN. t_o
RADIUS - IN.
DIAMETER - IN.
SHELLS, O.D.
HEADS, I.D.
SHELLS I.D.
CODE LOWER I.D. LIMIT

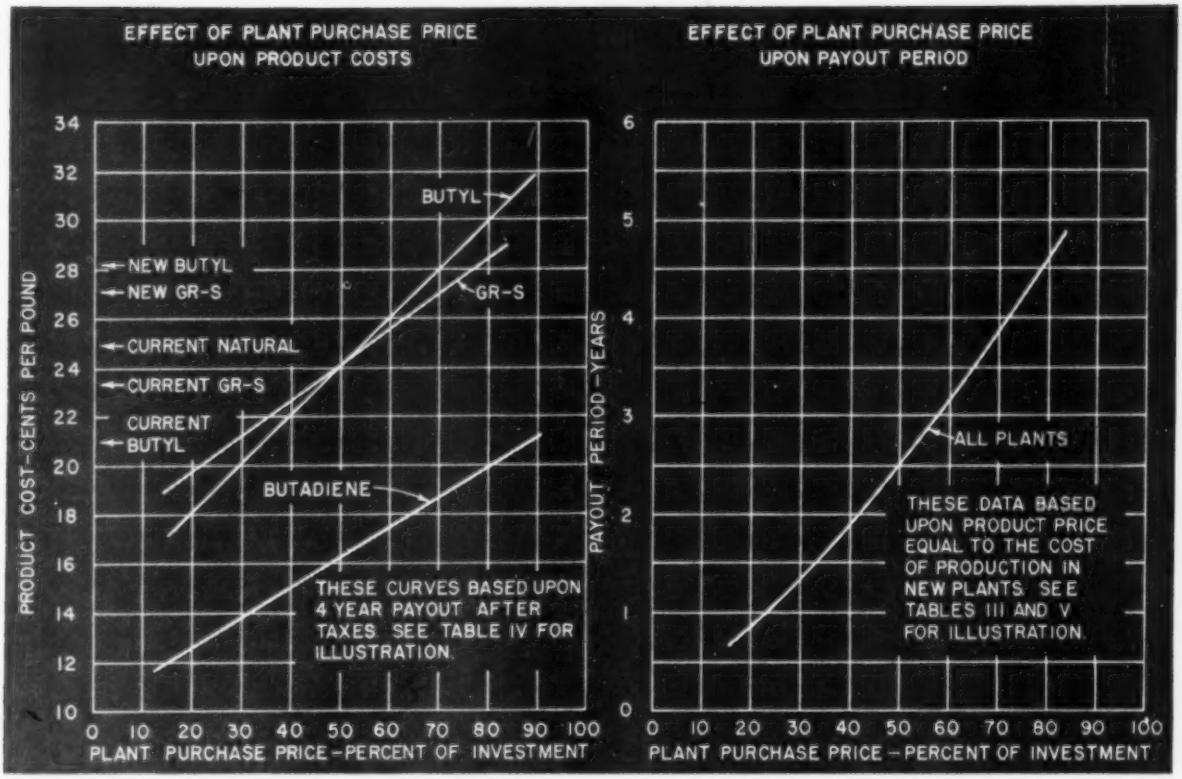


Figure 1.

Figure 2.

A Critical Study of the—

Selling Price of Synthetic Rubber Plants

An engineers' eye-view of the price the government should set on its synthetic rubber facilities, giving full consideration to original investment, replacement cost and raw material availability.

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IN KEEPING WITH the American tradition of private enterprise, the U. S. government is entering upon the final phases of a program which was designed to transfer the government owned synthetic rubber and rubber component producing plants to private ownership. These plants provide the bulk of the nation's rubber producing capacity. A major industry is to change ownership. What are these plants worth? For how much will they be sold? Numerous statements have been made wherein a finite value was assigned to these facilities, and these values have varied from 25 percent to over 100 percent of the present investment. Most of the statements can be justified, but only insofar as an individual plant is concerned, and not for the industry as a whole. It is the purpose of this paper to present various factors affecting plant value and to show how they can influence the selling price of these facilities. This discussion is based upon the premise that the Gulf Coast plants will set the basic disposal pattern since they are generally comparable in type and in proximity to raw materials and consumers.

At the very beginning of World War II over 90 percent of the world's supply of natural rubber fell into enemy hands, leaving this country in the position of having to fight a global war with less than one year's normal requirements of rubber in public and private stockpiles. The only solution to this problem was to quickly develop a synthetic rubber industry large enough to supply almost all of the rubber needs of the country at war. Although some progress had al-

ready been made in synthetic rubber production by private companies, the urgency of the situation made it necessary that the government undertake the financing and over-all direction of the project through the use of private companies to design, construct, and operate the facilities. Almost $700 million was spent on the program which included a total of some 51 plants including raw material and associated chemical plants. Since the war, many of these plants have been disposed of since they were either nonessential to the needs of the rubber program or competitive producers outside of the general synthetic rubber field. The government has concluded that the national security and the competitive status of synthetic compared to natural rubber is such that the competitive facilities remaining under federal ownership may now be safely sold to private industry. These facilities which are to be offered for sale are shown in Table I. This list includes all remaining government owned plants except for two alcohol butadiene plants and three miscellaneous plants which have been judged to be noncompetitive producers.

In these remaining plants, the nation's supplies of GR-S type and butyl type rubber are produced. GR-S type rubber is a copolymer of butadiene and styrene. Styrene production facilities were originally included in the rubber program, but most of the plants have been sold since the uses of styrene apart from rubber demands are sufficient to establish a stable, free market. Butadiene, however, is produced in government plants which use alcohol, normal butylene, or butane as raw materials. Alcohol-based butadiene is high priced as a result of the expensive raw material. The butadiene derived from butylene supplies the bulk of the butadiene demand. The latter type plants receive the butylene feed from adjacent petroleum refineries and are generally quite integrated with the particular refinery operations. The butadiene plants which utilize butane as a raw material are practically independent of any adjacent refining facilities due to the wider availability of butane. The two plants producing butyl rubber, a copolymer of isobutylene and isoprene, derive their raw material from nearby petroleum refining operations.

Federal policy on rubber matters and authority for operation of the synthetic rubber industry are set forth in the Rubber Act of 1948. This act, as extended in subsequent sessions, expires March 31, 1954. In compliance with provisions of this act, the Reconstruction Finance Corporation, on March 1, 1953, placed in the President's hands a report outlining a program for disposal of the rubber producing facilities to private industry. On April 14, 1953, the President in a message to Congress recommended prompt enactment of disposal legislation along the basic outline of the RFC report. It is anticipated that upon completion of hearings, Congress will pass legislation providing for the sale of these facilities.

TABLE I

Government Synthetic Rubber Facilities Included in Disposal Program

(Dollar Amounts Are in Thousands)

(From Yohalem Report, RFC to President, Dated March 1, 1953)

Plancor No.	Present Operator	Location	Original Investment	Present Investment	Net Book Value at Dec. 31, 1952	Maximum Annual Capacity
	Copolymer Plants (GR-S)					
876	Copolymer Corp.	Baton Rouge, La.	$ 7,332	$ 9,276	$ 4,148	40,000 LT
127	Firestone Tire & Rubber Co.	Akron, Ohio	7,766	7,630	3,041	30,000 LT
1056	Firestone Tire & Rubber Co.	Lake Charles, La.	13,061	15,846	7,697	99,600 LT
877	General Tire & Rubber Co.	Baytown, Texas	7,829	9,983	5,404	44,000 LT
983	B. F. Goodrich Co.	Port Neches, Texas	16,047	21,664	9,694	90,000 LT
980	B. F. Goodrich Co.	Institute, W. Va.	18,398	18,387	7,471	122,000 LT
126	Goodyear Synthetic Rubber Corp.	Akron	7,548	8,186	3,550	15,200 LT
956	Goodyear Synthetic Rubber Corp.	Houston	13,415	15,246	7,242	99,600 LT
1278	Kentucky Synthetic Rubber Corp.	Louisville, Ky.	6,865	8,932	4,298	44,000 LT
611	Midland Rubber Co.	Los Angeles	15,080	15,822	7,759	89,000 LT
982	Phillips Chemical Co.	Borger, Texas	8,842	10,438	4,664	66,000 LT
129	U. S. Rubber Co.	Naugatuck, Conn.	8,357	10,123	4,078	22,200 LT
983A	U. S. Rubber Co.	Port Neches	16,046	14,326	7,277	89,400 LT
	Total Copolymer		$146,586	$165,859	$ 76,323	860,000 LT
	Butyl Plants (GR-I)					
1082	Humble Oil & Refining Co.	Baytown	$ 25,937	$ 24,690	$ 8,226	43,000 LT
572	Esso Standard Oil Co.	Baton Rouge	25,882	28,491	9,378	47,000 LT
	Total Butyl		$ 51,819	$ 53,181	$ 17,604	90,000 LT
	Butadiene Plants—Petroleum					
706	Cities Service Refining Corp.	Lake Charles	$ 17,029	$ 17,703	$ 3,704	60,000 ST
152	Copolymer Corp.	Baton Rouge	8,762	7,711	1,470	23,000 ST
485	Humble Oil & Refining Co.	Baytown	18,790	18,772	3,899	49,000 ST
933	Neches Butane Prod. Co.	Port Neches	56,693	58,357	12,028	197,000 ST
484	Phillips Chemical Co.	Borger	35,682	42,239	11,676	71,200 ST
1063	Sinclair Rubber, Inc.	Houston	30,889	31,547	8,258	78,000 ST
963	Shell Chemical Corp.	Torrance, Calif.	19,917	20,281	4,061	61,000 ST
1593	Standard Oil Co. of Calif.	El Segundo, Calif.	7,859	7,862	1,159	
	Total Butadiene—Pet.		$195,621	$204,472	$ 46,255	539,200 ST
	Styrene Plants					
929	Dow Chemical Co.	Los Angeles	$ 12,558	$ 15,131	$ 4,199	57,000 ST
	GRAND TOTAL		$406,584	$438,643	$144,381	

NOTES—Plancor 1953 operates in tandem with Plancor 363. Original investments are for August 31, 1945, taken from Interim Report of Surplus Property Administration January 14, 1946.

Value of Facilities

Since the announcement that the government was instituting a definite plan for disposal of the rubber facilities, there has been a great deal of conjecture as to what the selling price should be for the various plants. So far the estimates for the total value of those offered have ranged from the government's own depreciated or net book value of $145,000,000 to more than the current investments which total approximately $440,000,000.

The position of the government in this matter has been somewhat clarified recently by the release of the RFC report which states, "—what can be obtained for the facilities can be determined only after a canvassing of the market. Therefore, no specific method for determining price is recommended here."

This bulletin goes further to specifically reject the viewpoint that the plant book value should determine the maximum purchase price. Basically, the purchase price of a synthetic rubber facility must depend upon its competitive position in the post disposal era not only with new plants but with other existing plants. In order to establish a pattern for evaluation of existing plants, consider the Gulf Coast facilities. These plants are generally similar in type and location and represent the following percentages of the total government owned facilities.

Plants	Gulf Coast Capacity as Percent of Total
Butadiene (from petroleum)	76%
GR-S	55%
Butyl	100%

This segment of the industry is of sufficient size to set the general pattern for disposal. Average figures developed for these Gulf Coast plants can be used as a basis for developing the status of the various individual plants not only in the Gulf Coast area but throughout the U. S.

But first, a value must be set upon these Gulf Coast facilities. This value must be such that the total cost of producing rubber will not exceed the product price as set by new plants. This product cost must include sufficient profit to attract the investment required to purchase the plants. While certain of the production cost items are readily obtainable, there are others

which are controversial and which affect the final product cost significantly. These latter deserve more detail discussion.

DEPRECIATION. Like automobiles and lawn mowers, chemical plants wear out, and when they are operated beyond the limit of their useful lives, they become more trouble than they are worth. Thus, as a plant produces and grows older, its life or ability to produce is used up. This loss in plant value is considered as a cost of manufacturing and is called depreciation. As the product is sold, that portion of the income that results from the depreciation charge is placed in a depreciation reserve which is used to replace portions of a plant which are worn out and, finally, when the whole plant is worn out, to build a completely new plant. Depreciation is not profit and should not be so considered. It represents the recovery of money invested in the producing facilities.

In addition to the loss of the physical ability to produce, a plant loses value as a result of the steady advance of science and technology. In other words it becomes obsolete. As a plant's product becomes less and less in demand, the plant becomes less valuable, although it may still be able to produce. Normal obsolescence is considered to be included in the depreciation term as generally used. Abnormal obsolescence, or the devaluation of a facility by some sudden development is recognized, but has no part in the depreciation term as generally used.

While simple in principle, the application of the depreciation concept can become quite complex. Much controversy has occurred in establishing allowable depreciation rates. This stems from the fact that any *excessive* depreciation is actually profit which escapes taxation since the Bureau of Internal Revenue regulations consider depreciation as a legitimate item of expense deductible from income before tax computation. Assignment of finite values to the depreciation allowance is largely a matter of judgment, since these concepts do not lend themselves to precise measurement. Using allowable rates established by the Bureau of Internal Revenue, these plants have an average life of 18½ years. While it is not the intention of this paper to enter into controversy over depreciation rates, it should be pointed out that, since part of the depreciation must be reinvested in replacing worn out equipment, an allowance greater than 100/18.5 or 5.4 percent per year is required in order to recover the original investment in 18½ years. However, the 18½ year life expectancy is considered reasonable. Some ten years have expired and by virtue of 8½ years remaining life, these plants have depreciated 54 percent in value.

While a plant depreciates for time in use, it can also increase in value due to such things as rising costs. This has occurred in the case of synthetic rubber. In assigning a depreciated value to these plants, the replacement value is determined and then depreciated for time in service. As discussed later, new plants cost 175 percent of the existing plants. Depreciating this figure by 54 percent gives a depreciated replacement value equal to 80 percent of the current investment.

PROFIT. Federal operation of the rubber facilities has been essentially on a nonprofit basis. In private operation, of course, there must be profit considerations to attract the capital required to purchase these plants. In new ventures, financial circles view with disfavor investments with a net return less than about 12 percent per year of the investment, or a payout for a plant of about 8 years. For investment in an existing facility with over half its life expended, it is felt that profit should be sufficient to payout the plant purchase price in a shorter period of time. How short a time is a matter of individual decision depending upon such items as these:

- Pending developments which would render present plants obsolete.
- Need of the facilities to supply raw materials to other processing plants or to satisfy commitments.
- Estimates of how long current products will command a large market.

Opinions will vary on payout time, but the more reasonable figure is believed to be in the neighborhood of four years for these existing plants.

FEDERAL TAXES. Another item of expense will be the federal taxation which accompanies profit. Rate of taxation will vary among companies, but the chemical industry averages for former years are as follows:

1942-1945	59 percent of profits
1946-1950	41 percent of profits
1951-1952	62 percent of profits

During the former and latter periods the excess profits tax was in effect. When the excess profits tax expires it is expected that the basic tax rate will be boosted to about 55 percent.

In addition to these cost considerations, there are other factors which should receive serious study in plant evaluation. These include:

- Cost of new plants.
- Prior plant sales.
- Natural rubber competition.

COST OF NEW PLANTS. The original construction of the rubber facilities was carried out in 1943 and 1944. Some additional investments have been made since that time, and the current average investments for the Gulf Coast butadiene from butylene, GR-S, and butyl plants are given in the following tabulation. Since the time of original construction, costs have increased about 75 percent, which means the identical plant today would cost 75 percent more than the present investment. In the case of new plants designed to take advantage of operat-

Average Gulf Coast Investments Per Annual Ton

PLANT	Current Government Investment	Present Cost for New Identical Plant	Present Cost for Newly Designed Plant
Butadiene from butylene	$330/ST	$580/ST	$470/ST
GR-S	$180/LT	$320/LT	$260/LT
Butyl	$590/LT	$1030/LT	$830/LT

TABLE II

Prior Sales
Major Synthetic Rubber Facilities
(Figures are 1000 Dollars)

TYPE PLANT	Location	Capacity Tons Per Year	Date Sold	Investment	Estimated Depreciated Replacement Value	SALES PRICE		
						Dollars	Percent of Depreciated Replacement	Percent of Investment
Copolymer	Louisville, Ky.	60,000 LT	Jan. 1947	$10,921	$12,000	$ 4,187	35%	38%
Styrene	Texas City, Tex.	50,000 ST	Oct. 1946	$19,273	$21,100	$ 9,908	47%	51%
Styrene	Kobuta, Pa.	37,500 ST	Oct. 1946	12,242	13,800	3,265	24	27
Styrene	Velasco, Texas	50,000 ST	Feb. 1947	17,828	20,500	14,518	71	82
Sub-Total for Styrene				$49,343	$55,400	$27,691	50%	56%
Neoprene	Louisville, Ky.	60,000 LT	Jan. 1949	$37,658	$41,800	$13,300	32%	35%
TOTAL				$97,922	$109,200	$45,178	41%	46%

Note: This table includes only those plants which are of sufficient economic value to be of interest.

ing experience, new ideas, and new techniques, it is reasonable to expect that plants of comparable capacity could be erected for about 80 percent of this replacement value.

PRIOR PLANT SALES. In considering the value which might properly be placed upon these facilities, it is in order that a review be made of rubber facilities which have been disposed of in prior years. In a report to the President by John R. Steelman, January, 1950, eighteen plants are listed as having been sold prior to that date. On the whole these plants with a total investment of $165.2 million brought a return of $57.3 million, or 35 percent of the investment. Eleven of these plants were either of little value, producers of miscellaneous chemicals, uneconomical producers, or so integrated with private facilities as to have a low value to outside interests. A styrene plant representing an investment of $9.5 million was sold jointly with an alcohol-butadiene plant with an investment of $37.9 million. Selling price for the two was $9.35 million and although most of the value is presumed to reside with the styrene plant, for the purpose of this study it is not possible to assign a finite percent of investment to either one of the two. Data for the remaining five plants are tabulated in Table II. The total money recovered in the sale of these plants represented 46 percent of the investment and 41 percent of the replacement value depreciated for time in service. Individual plants varied quite widely from this average. It might be expected that a fairly uniform pattern would exist among the styrene plants since these were of comparable size and type, but it is within this group that the highest and lowest returns occur. While a more rigorous study of these data may bring these figures more in line, it can be concluded at this point that certainly some degree of buyer resistance will develop if the disposal price of the remaining plants moves beyond the range of 50 to 60 percent of the depreciated replacement value.

NATURAL RUBBER. An evaluation study must include consideration of natural rubber with which synthetic must compete. Natural rubber prices are extremely sensitive to supply and demand relations and in the past have varied over wide extremes. Since the end of World War II the price of natural has ranged between 16 and 73 cents per pound, and it is currently selling at 25 cents per pound. Some observers are of the opinion that world rubber demand will increase, and since foreign users are not adapted to the use of synthetic, the price of natural will be strengthened over the next few years. While this may be true, it would be unwise for synthetic prices to be placed much in excess of natural rubber. Should this occur, domestic consumption would swing to natural. It must also be realized that natural rubber prices could drop. Some protection against abnormally low natural rubber prices must be provided to protect the synthetic industry, and it is probable that the disposal legislation will provide for some safeguards so that the industry will remain intact.

PLANT EVALUATION. The foregoing presents the basic method and the factors to be considered in evaluating the *average* of the Gulf Coast plants. The finite values to be assigned these various factors are subject to many different opinions. By way of illustration, certain values have been selected and used to determine the relationship of plant purchase price with the future rubber economy. These results are given in Tables III, IV and V and in Figures 1 and 2.

Table III is a tabulation of costs items which determine the price of rubber from new plants. Raw material prices and the basic conditions used are given in this table.

Table IV shows sample calculations for the cost of rubber in existing plants, based upon the conditions shown. In developing these costs, it is considered that production costs with private operation will be higher than with federal operation, due to additional items of expense such as sales, expense, and research. It is also concluded that the production costs in existing plants will be greater than in new plants. One reason for this is the fact that these plants are entering the old age period where repair and replacement costs will increase over those of prior years. Purchasers of these plants must meet these costs without benefit of unused depreciation reserves from former years.

Table V gives sample figures for developing the payout period for the existing plants, based on a set product price and varying plant purchase price.

Figure 1 is a plot of product costs versus plant purchase price (based upon four-year payout) showing also current prices for butyl, GR-S, and natural rubber (No. 1). On the basis with which these curves were pre-

TABLE III

Coverage Cost of Rubber in New Plants
(Production at 100% of Capacity)

	Butadiene	GR-S	Butyl
Plant Investment $/annual ton	$470/ST	$260/LT	$830/LT
Cost of Product, ¢/Pound			
Raw Materials	4.9[1]	17.3[2]	4.1[3]
Production Costs[4]	4.7	5.3	9.6
Depreciation (18½ year life)	1.3	0.6	2.0
Interest, taxes, and insurance (6% of investment)	1.4	0.7	2.2
Net Profit (8 year payout)	2.9	1.4	4.7
Federal taxes @ 55% of gross profits	3.6	1.8	5.7
Total Product Cost	18.8¢/lb	27.1¢/lb	28.3¢/lb

[1] Normal butylene at 17¢/gallon.
[2] Butadiene at 18.8¢/lb, styrene at 18¢/lb.
[3] Isobutylene at 17¢/gallon.
[4] Utilities, labor, chemicals, supplies, maintenance, administration and overhead, royalties, sales expense, and research and development.

TABLE IV

Cost of Rubber in Existing Plants—Private Operation
(Production at 100% of Capacity)

	Butadiene	GR-S	Butyl
Current Investment, $/annual ton	$330/ST	$180/LT	$590/LT
Plant Purchase Price, Percent of Investment	50%	50%	50%
Plant Purchase Price, $/annual ton	$165/ST	$90/LT	$295/LT
Cost of Product, ¢/Pound			
Raw Materials	4.9[1]	15.5[2]	4.1[3]
Production Costs[4]	5.3	5.6	10.3
Depreciation (8½ years life remaining)	1.0	0.5	1.6
Interest, taxes, and insurance (6% of investment)	0.5	0.2	0.8
Net Profit (4 year payout)	2.1	1.0	3.3
Federal taxes @ 55% of Gross Profit	2.5	1.2	4.0
Total Product Cost	16.3¢/lb	24.0¢/lb	24.1¢/lb

[1] Normal butylene at 17¢/gallon.
[2] Butadiene at 16.3¢/lb, styrene at 18¢/lb.
[3] Isobutylene at 17¢/gallon.
[4] Utilities, labor, chemicals, supplies, maintenance, administration and overhead, royalties, sales expense, and research and development.

TABLE V

Payout Period of Existing Plants
(Production at 100% of Capacity)

	Butadiene	GR-S	Butyl
Current Investment, $/annual ton	$330/ST	$180/LT	$590/LT
Plant Purchase Price, Percent of Investment	50%	50%	50%
Plant Purchase Price, $/annual ton	$165/ST	$90/LT	$295/LT
Cost of Product, ¢/Pound			
Raw Materials	4.9[1]	17.3[2]	4.1[3]
Production Costs[4]	5.3	5.6	10.3
Depreciation (8½ year life)	1.0	0.5	1.6
Interest, taxes, and insurance (6% of investment)	0.5	0.2	0.8
Total Costs	11.7	23.6	16.8
Selling Price (from Table 3)	18.8	27.1	28.3
Gross Profit	7.1	3.5	11.5
Federal taxes @ 55%	3.9	1.9	6.3
Net Profit	3.2	1.6	5.2
Payout, years	2.6	2.5	2.5

[1] Normal butylene at 17¢/gallon.
[2] Butadiene at 18.8¢/lb, styrene at 18¢/lb.
[3] Isobutylene at 17¢/gallon.
[4] Utilities, labor, chemicals, supplies, maintenance, administration and overhead, royalties, sales expense, and research and development.

pared, it is seen that as the plant purchase price exceeds 45 percent of investment, the synthetic rubber price moves above the current GR-S price. At 70 percent of investment, prices are equal to that of rubber from new plants, or 27-28c/lb.

Figure 2 is a plot of plant payout versus plant purchase price, and is based upon market prices as set by new plants. On this basis a four-year payout is obtained at a purchase price equal to 70 percent of the government investment, while at 45 percent, a two-year payout is obtained. It should be pointed out, however, that immediately after disposal, the price of synthetic rubber might not rise to that of rubber from new plants. In this case, in order to obtain a four-year payout, the plant purchase price must be less than 70 percent of investment. To narrow this spread, a detailed study must be made of the raw material and product markets to obtain reliable estimates of their future course. It would also require an examination of the interim period following disposal and before new plants can be put into production. A program based upon new plant production prices would not pay off in the required time if the product prices do not reach the designated level. Since the time for erection of new facilities (two years) is an appreciable portion of the probable payout period (four years), this consideration is worthy of a great deal of attention. It should also be pointed out that if studies indicate a lack of need for new facilities in the near future, it would be advantageous for these existing facilities to be sold at a value which would cause the product price to rise, not to that from new plants, but to an intermediate level. In this manner, the consumer market can adjust itself more gradually to rising rubber prices, and the competitive relationship between natural and synthetic can adjust itself in steps.

Factors Affecting Individual Plant Values

While it can be concluded that the plant purchase price for the Gulf Coast facilities should average some certain percentage of investment, this figure cannot apply to each individual plant. When the plants were constructed during the wartime emergency, the primary purpose was to get volume production of rubber as soon as possible. Expense was secondary and location, to a large extent, was based upon availability of raw materials which were not required by other vital programs such as aviation gasoline production. Consequently, nearly every one of the plants contain certain features which will cause its value to deviate from the Gulf Coast average. It is not within the scope of this article to attempt to assign finite values to the individual plants. To do so would require detailed study of each plant and consideration of those factors, discussed herein, which affect the cost of production and which in turn cause each plant to be more or less valuable than the average.

Construction Costs. From an examination of the present investment figures for butadiene and copolymer plants shown in Table 1, it may be seen that the investment per annual ton varies considerably. In some cases, this is a result of greater physical value, and in others, it is due to plant size. However, a large part of the difference among certain plants appears to have resulted from actual variation in construction cost. In evaluating these differences, it must be brought out that the plants, even of the same type, do not all include the same facilities.

Size. Both the copolymer and butadiene plants vary widely in production capacity, the largest of each group being eight times larger than the smallest. Allowance must be made for the higher production costs in the smaller plants.

Raw Materials. All of the butylene to butadiene plants receive their feed from nearby refineries. In those cases where a single refinery supplies butylene, an outside purchaser would have little raw material independence and there should be some compensation for this disadvantage. Certain of the plants utilize butane as a raw material, and since butane is more available, the raw material picture for these plants is considered good.

The Gulf Coast GR-S plants all are located near a single butadiene plant. The butadiene production and demand are not in balance at each location and there is considerable movement of butadiene throughout the area. A single butadiene supplier limits independence, of course, but this is less serious in GR-S considerations due to established raw material shipping within the area. Styrene supplies for the copolymer plants are sufficient and offer no problem.

In the case of the butyl plants, isobutylene is supplied by a single adjacent refinery. Here again feed stock independence is limited.

Integration. Several of the butylene to butadiene plants are dependent upon nearby refineries not only for their feed, but for certain important phases of processing. This is illustrated by the butyl-butadiene integration wherein the butyl plants remove isobutylene (an impurity in butadiene manufacturing) from normal butylene which is the butadiene plant feed stock. The butyl plant thus performs part of the purification required in butadiene manufacture. When these facilities are split into component parts, this sequence will be disrupted.

The copolymer plants depend upon adjacent butadiene plants to purify a recycle stream, but are otherwise relatively nonintegrated.

The butyl plants, apart from feed stock supplies, are relatively independent of adjacent facilities.

Utilities. In a number of cases, a common steam plant was constructed to serve several nearby rubber or component plants. Disposition of this common utility will, of course, affect the value of the plants.

Transportation. Those facilities which are near water transportation might be said to have an advantage over the inland plants.

Location. The preceding factors have been developed primarily for the Gulf Coast plants, but apply nevertheless to other sections of the country. There are other factors of a geographical nature which must be weighed in considering plants outside the Gulf Coast. These include the differences in utility and other processing costs in different sections, freight charges, raw material, and utilities available. Having set the pattern with the Gulf Coast plants, the evaluation of the other plants is made easier.

Summary

The Gulf Coast synthetic rubber and rubber component plants constitute the bulk of such facilities which may be sold by the government. These plants are generally comparable, and it is believed that their average disposal price can be used as the pattern for evaluating each individual plant throughout the country. This average disposal price should be such that the Gulf Coast plants can compete with new plants. In turn, the individual existing plants must compete with this Gulf Coast average, and the fair market price of the plants can be thus determined. On the basis of conditions used in this study, the fair value of the Gulf Coast plants is concluded to be above 45 and below 70 percent of the current investment. A closer figure can be obtained upon a more detailed study of raw material and product markets, and after a closer study of the interim period before new facilities can be put into operation.

Refinery Gasoline Desulfurized

By the Cycloversion process, octane improvement is 8 to 10 numbers at the 3 ml TEL level in this Mexico City plant.

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PETROLEOS MEXICANOS, the national oil company of Mexico, desulfurizes straight run gasoline and part of the thermally cracked gasoline in three of their largest refineries by use of the Cycloversion process. How the Cycloversion unit was fitted into the processing plan of the Mexico City refinery, its operation and the results obtained are as follows.

The Mexico City refinery, which was rebuilt in 1945, has two topping units with a total crude capacity of 55,000 barrels per day. However, only 50,000 barrels per day is actually charged, since this is the maximum capacity of the pipe line that brings the oil over the mountains from the Poza Rica production area to Mexico City. In addition to the crude stills, the processing units are a two-coil thermal cracking unit of 15,000 barrels per day capacity, an HF alkylation unit, an isomerization unit, light end fractionating facilities and the Cycloversion unit. The usual facilities for treating, blending, ethylizing, loading, etc., are also included in the plant.

The straight-run gasoline from the Poza Rica crude contains approximately 0.08 to 0.10 weight percent sulfur. By removing the sulfur compounds from this gasoline, it was found that an octane improvement of 8 to 10 numbers could be obtained at the 3-ml TEL level. Pemex found that the octane number improvement obtained by desulfurization made it much easier to supply the regular grade of gasoline and at the same time provide larger quantities of premium gasoline.

The Cycloversion unit equipment consists of two 12-by-26½-foot catalyst chambers, each containing approximately 80,000 pounds of bauxite catalyst, a process heater, product to charge heat exchangers, a product accumulator, charge and product pumps, and catalyst regeneration facilities. The nominal capacity of 12,000 barrels per day has been exceeded most of the time since the unit went into operation; and occasionally a charge of over 17,000 barrels per day has been processed successfully.

The normal processing temperature at the inlet of the catalyst chamber is 800 F. The production of gas at this temperature is very low and at times the chamber effluent product is totally condensed. The amount of carbon deposited on the catalyst is very small and as much as 750,000 barrels has been processed through a chamber before catalyst regeneration was necessary.

The crude received in Mexico City contains approximately 28 percent gasoline and lighter, as indicated in gasoline and lighter. Considerable light material, recovered in the absorption and stabilization plants in Poza Rica, is added to the crude before it is moved to the refinery, thus giving the Mexico City refinery an enriched synthetic crude carrying a far greater percentage of light material than other crudes in Mexico.

The gasoline and lighter material removed in the refinery topping units is collected in spheroid tanks. In the original processing plan, this material was charged to a depentanizing tower, with the pentane-free bottoms going to solid copper chloride treaters. The pentane and lighter overhead material was then charged to a depropanizer, where the propane and hydrogen sulfide were removed; the bottoms product was caustic washed, treated with dry copper chloride, and fractionated into iso- and normal butane, and iso- and normal pentane.

It is interesting to note how easily the Cycloversion unit fitted into the described flow by making use of the existing depropanizer to remove the additional amount of hydrogen sulfide that was produced.

Processing Plan

The raw straight-run gasoline from the spheroid tanks is now charged first to the Cycloversion unit, from which it goes directly to the depentanizing tower, thus requiring no additional storage. No other changes were necessary in the processing plan as described above, except, of course, that after removal of the hydrogen sulfide in the depropanizer, all products are sweet and require no further treatment. The iso-butane is used in HF Alkylation. The normal butane is used as charge stock for the isomerization unit and also as LPG. The isopentane goes into aviation gasoline blending. The normal pentane and heavier material is put into motor gasoline.

Because of the amount of light materials present in the charge to the Cycloversion unit, the improvement in octane number obtained on the motor fuel portion of the charge can best be shown by testing debutanized samples of the charge and product. Inspection tests of such samples are shown in Table 1, which indicates an improvement of ten Research octane numbers at the 3-ml TEL level.

Regeneration of the catalyst is accomplished by burning the carbon off with a mixture of air and superheated steam under controlled conditions. Thermocouples placed in the catalyst bed allow the progress of the burning to be closely followed and regulated. The catalyst in a chamber on this unit can be regenerated in less than 24 hours after processing straight-run gasoline for more than two weeks at desulfurization temperatures. When charging a mixture of cracked and straight-run, or when operating at reforming temperatures, the processing period is decreased. Still, the processing period on a given chamber is much longer than the time required for regeneration and permits a simple and unhurried regeneration operation.

TABLE 1

Inspection of Atzcapotzalco Perco Unit Samples

YIELD SUMMARY	Debutanized* Charge	Debutanized† Product
Yield, Vol. Percent ac—Rec'd Stock	82.5	81.5
Yield, Wt. Percent ac—Rec'd Stock	84.8	84.4
INSPECTION TEST RESULTS		
ASTM Distillation, E.		
First Drop	111	105
5 Percent Evaporated	130	122
10 Percent	142	137
30 Percent	178	184
50 Percent	222	228
70 Percent	266	271
90 Percent	315	318
95 Percent	333	335
End Point	359	359
Rec. Vol. Percent	98.5	98.5
Res. Vol. Percent	0.8	0.9
API Gravity at 60 F.	66.5	65.7
RVP, Psig at 100 F.	6.1	5.4
Lamp Sulfur, Wt. Percent	0.079	0.012
Mercaptan Sulfur, Wt. Percent	0.028	0.007
Hydrogen Sulfide, Wt. Percent	0.003	Trace
Doctor	Sour	Sour
Bromine Number	1.3	1.4
UOP K Factor	12.29	12.27
ASTM Octane Number:		
0 cc TEL Gal.	43.2	47.6
1 cc TEL Gal.	53.6	62.0
3 cc TEL Gal.	64.0	72.4
Research Octane Number:		
0 cc TEL Gal.	40.7	46.7
1 cc TEL Gal.	51.0	60.2
3 cc TEL Gal.	62.3	72.5

* Analysis of debutanized charge showed 1.1 weight percent (1.4 volume percent) C_4's.

† Analysis of debutanized product showed 0.6 weight percent (0.7 volume percent) C_4's.

Refining With Adsorbents

Part II

Efficiency of adsorbents must be evaluated. Decolorizing and desulfurizing properties are important in component separation.

V. A. Kalichevsky[1] and Kenneth A. Kobe[2]

THE FIRST ARTICLE in this series dealt with the preparation of adsorbents and the physical and chemical properties of each type. This second part discusses the efficiency of adsorbents and how to measure it, the reasons behind decolorizing and desulfurizing properties, and the latest developments in the use of adsorbents for the separation of petroleum fractions.

Evaluation of Adsorbents

Efficiency of adsorbents varies with the type of oil refined. Some adsorbents are most efficient in refining oils to light colors while others are best in the dark color ranges. Small variations in treating conditions may have a considerable effect on the efficiency of the adsorbents or change their relative positions. For these reasons, evaluation of the efficiency of the adsorbents in relation to a standard adsorbent and using a standard oil is of little value to the refinery. Likewise each refinery should revaluate the adsorbents every several years and make the necessary corrections for changes in the operating technique and the crude oil supply.

Evaluation of the adsorbents must be done in the laboratory because of the many uncertainties involved in plant operations. In making these laboratory evaluations the plant conditions must be reproduced as closely as possible. Satisfactory procedures were worked out for testing adsorbents used for contacting [109] and for percolating[9, 63, 159] oils. The oils used in this work must be the representative plant stocks. In testing percolation clays, they must be burned at temperatures used at the plant. The moisture content of the adsorbents should be adjusted.

Determination of the various properties of adsorbents in addition to the decolorizing power is desirable. Apparent density is measured if the adsorbents are bought on weight basis and handled on the volume basis. Moisture content affects transportatiation costs. The mesh of adsorbents may indicate filter rates although different adsorbents of the same mesh vary widely in filtering characteristics. The mesh of known adsorbents is, therefore, more indicative of their properties than the mesh of the unknown adsorbents. Retention of oil by an adsorbent might be estimated but this is of little interest because the spent adsorbents are washed with naphtha before discarding. Adsorbents retain normally about one third of oil by weight before and only a few percent of oil after the naphtha is applied. Standard fuller's earth is available for evaluating the decolorizing efficiencies of vegetable[126] but not petroleum oils.

Adsorbents are used primarily for decolorizing oils, but they may be required to fulfill additional duties. This may include improvement in demulsibility and oxidation characteristics, reductions in the acidity and the ash content, or an improvement in electrical and other properties of oils. If this is required, the necessary tests are conducted.

Simplified methods for testing adsorbents were developed. They might be of some interest in comparing adsorbents originating from the same source, but not for wide applications. The temperature rise on mixing bauxite with kerosene,[49] pinene[12] or terpenes[153] in a special apparatus known as "ergometer" is said to be indicative of the bauxite efficiency. Other suggestions include determination of adsorption of dyes like methylene blue[93] or malachite green[12] from water solutions, of swelling tendencies of clays in contact with water[45] or titration of clays with acids or alkalies.[47, 53, 149] Some clays adsorb from 0 to 275 c.c. of 0.1 normal sodium hydroxide solution per gram, others may adsorb acids[52, 137] or both alkalies and acids. Clays in water suspension migrate under the action of electric current. All of these tests will give erroneous results.[59, 158]

Very many natural adsorbents may be located all around the world, but a small portion of them is of practical value. Out of one thousand samples tested maybe only one or two are worthy of further studies.

Theoretical Principles

The theoretical adsorption equations[158, 173, 175] with the possible exception of the empirical relationship of Freundlich[66] are not applicable for evaluating the decolorizing efficiency of adsorbents. The Freundlich equation is subject to the usual limitations of empirical relationships.[105]

One of the difficulties encountered in applying the equation in practice is the absence of adequate methods for expressing the concentration of coloring matter in the oil in additive units. This coloring matter is not a chemically uniform substance and the composition of the oil is likewise not uniform. In addition to removing the coloring matter, the adsorbents may promote certain chemical reactions such as polymerization. These reactions are of much importance in decolorizing oils containing unsaturated hydrocarbons, such as cracked gasolines. Some of the polymerization reactions produce color bodies which dissolve in the oil. On prolonged contact the oil color may become lighter and then darker than the color of the original oil. Darkening of the oil color is often greater if the adsorbents are contacted in the presence of small quantities of air. Considering all these complications it is surprising that the Freundlich equation holds as well as it often does.

The Freundlich equation can be used only in estimating the decolorizing power of clays by the contact method. In using the Freundlich equation colors should be expressed on the "true" or additive color scale. The

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"Inspection of the Freundlich equation shows that the adsorbents are utilized most efficiently if they are applied countercurrently or if they are added to the oil fractionally, that the oils should be treated before and not after blending, and diluting the oil with colorless solvents changes the response of the oil to the adsorbents, and that the removal of coloring matter in terms of true color is easier from original oil than from the oil partially treated with the adsorbents. Some of these conclusions are applicable to commercial practice.

"The Freundlich equation may be further elaborated for expressing in simplified numbers the comparative results obtained with several adsorbents applied to the same oil, with the same adsorbent applied to different oils, or to the same adsorbent and the same oil but contacted at different temperature levels."

equation applied to petroleum assumes the form

$$\log \frac{C_o - C}{M} = n \log C + \log K$$

where C_o and C are concentrations of coloring matter in the oil ("true" colors) before and after the adsorbent is applied. M is the weight of adsorbent per unit volume or weight of oil and M and K are constants depending on the nature of adsorbent and oil, procedure employed and the treating variables. The equation produces a straight line on logarithmic paper if the color of the treated oil is plotted against the quotient of the color units removed and the quantity of adsorbent used.

Inspection of the Freundlich equation shows that the adsorbents are utilized most efficiently if they are applied countercurrently or if they are added to the oil fractionally, that the oils should be treated before and not after blending, that diluting the oil with colorless solvents changes the response of the oil to the adsorbents, and that the removal of coloring matter in terms of true color is easier from original oil than from the oil partially treated with the adsorbents. Some of these conclusions are applicable to commercial practice.

The Freundlich equation may be further elaborated for expressing in simplified numbers the comparative results obtained with several adsorbents applied to the same oil, with the same adsorbent applied to different oils, or to the same adsorbent and the same oil but contacted at different temperature levels.[46,139] This is done by dividing the two logarithmic equations into each other.

$$\frac{M'}{M} = \frac{K}{K'} C^{(n-n')} = \text{relative efficiency}$$

where M' and M refer to the quantities of the unknown and the standard clays, and n, n', K and K' are constants in the two basic equations.

No attempts were made for applying the equations to the removal of sulfur compounds and other substances from the oil except the color bodies.

In evaluating percolation clays, the following relationship might be of value.[74]

$$\log \frac{V(Do - Dc)}{W} = K + N \log \frac{D}{Do}$$

where

Do, D, and Dc are optical densities of feed, effluent and composite, respectively, V is the yield of the oil and W is the weight of clay used, K and N are constants.

Refining Action

Adsorbents were first applied by the petroleum industry for improving the color of the oil and for removing resinous and asphaltic substances left in the oil after sulfuric acid refining or distillation. The desulfurizing properties of adsorbents were utilized at a considerably later date. The most recent development is the use of adsorbents for separating oils into fractions of uniform chemical composition.

Water and Suspended Impurities

Adsorbents are very effective for removing water and suspended impurities from the oil, acting as dehydrating and clarifying agents. Water is adsorbed in preference to the coloring matter. If adsorbents are applied to the oil at low temperatures and the adsorbed water is not removed in processing the oil, the adsorbents must be dried to free their pores from moisture. The dehydrating action of adsorbents may be utilized for drying transformer oils or charging stocks to the refinery units but this is done usually by blotter pressing, sodium chloride towers and other conventional methods.

Adsorbents remove most of the additives. For this reason the additives should be added to the finished oils and not to the intermediate products.

Resinous and Asphaltic Substances

Resinous and asphaltic substances are removed by the adsorbents with the resulting improvement in the color of the oil. Raising the temperature and increasing the treating time often facilitate the removal of color bodies, but at very high temperatures or on prolonged contact reversion of color may occur. Difficulties experienced in the complete decolorization of some oils and the existence of colored aliphatic hydrocarbons[10] indicate that the resinous and asphaltic substances may not be the only petroleum constituents responsible for the dark color of the oil. Observations were reported that the presence of small quantities of air is necessary for promoting color reversion by the adsorbents.[158]

Sulfur Compound

Adsorbents vary in their desulfurizing characteristics. Some of them, like bauxite or alumina and silica gels are more effective than others, like fuller's earth. Percolation is much more efficient than batch contacting for removing sulfur compounds by adsorption. Large quantities of adsorbents are usually required for obtaining a substantial degree of desulfurization as shown by the data presented in Table 4.[115]

TABLE 4

Effect of Percolation Through Fuller's Earth on Sulfur Content, Carbon Residue and Viscosity of a Lubricating Oil

Material	Gravity API	Sulfur Content Percent by Weight	Carbon Residue Percent by Weight	Viscosity SUV 210 F.
Unfiltered Stock...	41.6	0.134	2.25	156
Stream after Oil Yield of:				
10 bbls..	48.3	0.02	0.027	87
25 bbls..	46.2	0.05	0.115	95
75 bbls..	43.2	0.08	0.546	125
150 bbls..	42.4	0.13	0.932	135
300 bbls..	41.9	0.13	1.49	140
500 bbls..	41.8	0.13	1.61	140
600 bbls..	41.5	0.13	1.79	140

The desulfurizing action of various adsorbents and sulfuric acid on solutions of pure sulfur compounds in naphtha is shown in Table 5.[194] Twenty-eight pounds of adsorbents were used per barrel of solution at room temperature or 50 pounds of sulfuric acid per barrel.

The tabulated data show that sulfuric acid is a much more effective desulfurizing agent than the adsorbents and that silica gel is the most effective adsorbent. However, such comparisons may be misleading because the method of preparing the adsorbents is highly important.[195] This explains many discrepancies in the results reported by different laborato-

ries. Aluminum oxide shown in the table seems to be less effective than some of the gels[18] recommended for desulfurizing oils. Activated carbon impregnated with sodium hydroxide is claimed to be a very efficient agent for removing mercaptans.[183]

The total sulfur content of gasoline filtered through an adsorbent may first decrease and then increase indicating desorption of sulfur compounds.[133]

Wide variations in the nature of sulfur compounds present in different oils result in similar variations in the desulfurizing action of adsorbents. Percolation of polymers from the manufacture of di-iso-butylene through silica gel in 36.6:1 volume ratio at 80 F. reduced the sulfur content from 0.81 to 0.084 percent. This is an exception as very large quantities of adsorbents are usually required for desulfurizing oils[187,188] making such procedures uneconomical. If the quantity of adsorbents used is large even fuller's earth shows marked desulfurizing characteristics.[72]

In the past, Burmah Oil Company used bauxite for desulfurizing kerosine. Bauxite was charged to the filters direct from the kilns to avoid adsorption of moisture. The sulfur content of kerosine was reduced from 0.134 to 0.02 percent with 80 to 360 pounds of bauxite per barrel. If bauxite was charged to the filters from storage bins the sulfur content of the filtrate rose to 0.11 percent, presumably due to adsorption of water. Susceptibility of bauxite to moisture varies with the oil. For instance, the sulfur content of triisobutylene was reduced from 0.103 to 0.018 percent by percolating through bauxite containing up to three percent moisture.

A cyclic adsorption process for desulfurizing cracked naphtha and separating it into fractions has been worked out.[50,51] Silica gel is used as the adsorption medium. Dry naphtha is freed of organic acids, nitrogen bases and other very strongly adsorbed compounds which cannot be removed from silica gel with hot propane used in the regeneration step. Naphtha is then passed through the silica gel adsorption columns which are shifted in counter-direction to the liquid flow on a regular cycle through the raffinate refining, extract enriching, stripping with hot propane, and cooling zones. The data show that using 0.08 gallon of feed per pound of silica gel, 0.7 volume recycle and 2.0 volumes of propane the sulfur content of thermally cracked naphtha was reduced from 1.22 to 0.05 percent. The yield of the desulfurized naphtha was 75-80 percent and the life of the adsorbent exceeded six months.

Nitrogen Compounds

Partial or complete removal of nitrogen compounds is accomplished in normal treating operations and those that are left in the oil have no effect on the properties of finished products which would necessitate their elimination. As a result little work was done on the effect of adsorbents on nitrogen compounds in petroleum. Such studies are relatively difficult because of absence of simple analytical methods for nitrogen determination.

Nitrogen compounds of basic nature are retained to a considerable extent by such adsorbents as fuller's earth.[55,72]

Oxygenated Compounds

Many oxygenated compounds are removed by the adsorbents preferentially to the hydrocarbon substances. This removal is less complete than is often expected and depends on the structure of the oxygenated compounds and on the length of the hydrocarbon radical.

Aliphatic acids are very efficiently removed by the clay, but the naphthenic acids are little affected.[180] Adsorbents differ in this respect; bauxite removes naphthenic acids with greater ease than fuller's earth. The use of sulfuric acid in combination with the adsorbents improves the extraction efficiency considerably.[118]

The presence of polar compounds like acids, alcohols, aldehydes and others in the oil has an adverse effect on the decolorizing efficiency of adsorbents. Wetting adsorbents with alcohols modifies considerably their adsorbent properties.

Hydrocarbons

Hydrocarbons belonging to different chemical series or composing the same series are adsorbed preferentially. This is reflected in the differences in properties of the charge stock and the filtrate known as Day's phenomenon. This difference in properties is easily detected on percolation; the difference disappears gradually with the increase in the volume of the oil passed through a filter. In contact filtration the difference in physical constants between the charge stock and the finished oil is difficult to detect because of the small quantities of clay involved.

Preferential adsorption results in the stepwise displacement of the individual hydrocarbons from the adsorbents in the order of tenacity with which they are retained. The order of adsorption is not the same for all the adsorbents.[168] Silica gel adsorbs first the aromatic hydrocarbons followed by diolefins, mono-olefins, naphthenes and paraffins in the order mentioned.[127,128] It is very effective for separating aromatic from aliphatic hydrocarbons and for isolating the individual paraffinic hydrocarbons from their mixtures. Activated fuller's earth gives a sharp separation between paraffins and olefins. Alumina gel is very satisfactory for isolating the aromatic hydrocarbons from their mixtures. Activated carbon may be used instead of silica gel. The choice of the experimental conditions and of the developing solutions is important for obtaining the desired results.[61]

Differences in the adsorption characteristics of the hydrocarbons belonging to the same series result in overlaps between the series. The use of narrow boiling fractions is important for effective separations in order to minimize variations in molecular weight and structure.[34,78,95,129] An increase in the length of the hydrocarbon chain increases the tenacity but reduces the rate of adsorption.[14] The same general principles apply to petroleum constituents other than hydrocarbons.

Chromatographic analytical methods utilize differences in the adsorption characteristics of the individual hydrocarbons or other petroleum constituents.[191] Many procedures were developed, such as separation of aromatics from the light petroleum fractions,[43,142,189] isolation of pentane, hexane, heptane, iso-octane and other paraffinic hydrocarbons from their mixtures. These procedures were extended to the high-boiling petroleum fractions,[4] like gas oil,[40] lubricating

TABLE 5

Removal of Sulfur Compounds From Naphtha Solutions With Adsorbents and Sulfuric Acid

SULFUR COMPOUND	PERCENT REMOVAL				
	Silica Gel	Fuller's Earth	Aluminum Oxide	Sulfuric Acid	
				93 Percent	Fuming
Free sulfur	8	4	4	0	0
Hydrogen sulfide	12	12	12	12	12
Isoamyl mercaptan	69	3	17	24	100
Dimethyl sulfate	100	100	25	100	100
Methyl-p-toluene sulfonate	80	67	0	77	100
Carbon disulfide	0	0	0	0	0
N-Butyl sulfide	57	3	0	93	100
N-Propyl sulfide	37	11	5	58	100
Thiophene	11	11	0	89	100
Diphenyl sulfoxide	100	100	0	90	100
N-Butyl sulfone	100	100	12	100	100

oil distillates[15, 127] and used automotive oils.[139] The Aromatic Adsorption Index may be used for evaluating efficiencies of adsorbents.[21] Similar methods are applicable for separating sulfur compounds from each other and from the aromatic hydrocarbons.[84]

Chromatographic analysis permits separation of paraffin wax into fractions of different melting points.[14] The method was recommended for the identification of Pennsylvania crude oils.[192]

Adsorbents may not only adsorb but also polymerize the unsaturated hydrocarbons. This is reflected in an increase in the boiling point of the filtered fraction. The rate of polymerization of diolefins is much higher than that of the olefins but varies considerably with the individual hydrocarbons.[56] Some hydrocarbons like isobutylene are polymerized at temperatures as low as —112 F. However, acetylenes and pyrrole formed no polymers after a two year contact with fuller's earth.[122]

Considerable heat may be evolved during adsorption. If natural gas is passed through charcoal placed in a metal tube several heat waves of diminishing intensity may be detected passing through the bed. These heat waves are caused by the adsorption of the individual hydrocarbons from the mixture.

Commercial processes were developed for separation of hydrocarbon mixtures. These processes may be applied to the separation of aromatic hydrocarbons,[191] the paraffinic hydrocarbons from the naphthenes or the straight-chain from the branch chain paraffins and olefins. The Arosorb process is in commercial use.[7, 51, 82, 85] The quantity of the aromatics recovered depends on the desired purity.[190] For instance, ninety percent of aromatics of 98 percent purity or 98 percent of aromatics of 90 percent purity may be recovered.[8] The Cyclic Adsorption Process[51] has been developed for separating aromatics or olefins from saturated aliphatic hydrocarbons. Fixed beds of adsorbents of fine particle size are used in preference to the moving beds.

Effect on Oil Properties

Adsorbents are very efficient decolorizing agents. They improve also the demulsibility characteristics and electric properties of oils. They act as clarifying agents. In many respects adsorbents act similarly to sulfuric acid and other conventional refining agents, but the quantity of adsorbents required to obtain a radical improvement in oil properties is prohibitive. In the past Pennsylvania oils were refined with adsorbents only, but most of them are pretreated now with solvents.

The effect of adsorbents applied in commercial quantities on the properties of lubricating oils is shown in Table 6.

Color of the oil is improved considerably.

Specific gravity is slightly lowered and the API gravity is raised. The change in gravity seldom exceeds a few tenth degree API but may reach five and more degrees if the gravity of the first portions of filtrate is compared with the gravity of charge stock. The difference in gravity is less if the stock was pretreated with chemicals before the adsorbents are applied. It is also less for the distillate than for the residual stocks and varies with the source of crude oil.

Viscosity is lowered slightly but it is usually noticeable if the oil is refined by percolation.[1, 22, 112] Viscosity of the filtrate first emerging from the filters may be several hundreds seconds lower than that of the charge stock.

Viscosity index and viscosity-gravity constant show minor improvements, usually negligible.

Carbon residue may be improved considerably if the oil contains appreciable quantities of asphalt.

Flash and fire points are not affected.

Pour and cloud points may increase due to the removal of resinous and asphalting substances having pour point depressant characteristics.

Neutralization number and demulsibility characteristics are improved. Stability of the oil is improved slightly. The improvement in stability is due often not to the changes in chemical composition but to the removal of suspended impurities acting as oxidation accelerators.

Very occasionally the properties of an oil may change in the opposite direction from normal.[184] For instance, the pour point might be lowered or the viscosity of a lubricating oil may rise after percolation through clay. These variations cannot always be explained by the removal of asphalt or by polymerization.

Changes in oil properties on percolation normally observed in commercial practice using fuller's earth in quantities close to the upper limit are shown in Tables 4[115] and 6.

The light petroleum distillates containing unsaturated hydrocarbons may show an increase in the gum content, specific gravity and end point when decolorized with the adsorbents. Some of them may darken instead of improving in color.

End of Part II. Part III will appear in an early issue.

NOTE

All references appeared with Part I, used in the June issue of PETROLEUM REFINER.

TABLE 6

Effect of Clay Percolation on Properties of Refined Oils

	RESIDUAL OILS															
	STOCK A				STOCK B				STOCK C				STOCK D			
Yield on solvent refining, % Vol	86.2		73.5		75.0		69.0		85.0		60.0		72.3		63.4	
Clay percolation	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Inspections:																
Gravity, API	25.2	25.9	27.5	27.7	28.0	27.9	28.9	28.9	22.8	23.1	26.8	26.9	27.0	27.5	28.7	29.0
Pour, °F.	5	5	10	10	0	0	10	10	5	10	—5	—10	10	10	15	20
Viscosity, SUV, 100 F.	1850	1670	1340	1305	1400	1295	1245	1180	3040	3030	1425	1430	1910	1760	1530	1390
Color, Lovibond	525	200	325	200	315	70	395	70	110	95	7	4	>750	80	>750	24
Carbon residue	1.1	0.8	0.5	0.4	0.7	0.3	0.6	0.3	0.7	0.6	0.1	0.1	1.0	0.6	0.7	0.2
Viscosity index	84	87	96	96	98	94	99	99	63	63	83	83	104	104	108	108

	DISTILLATE OILS											
	STOCK E				STOCK F				STOCK G			
Yield on solvent refining, percent volume	88.0		68.5		86.0		51.2		92.0		72.9	
Clay percolation	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Inspections:												
Gravity, API	30.7	31.0	32.5	32.6	32.5	31.9	35.4	35.4	30.5	30.4	32.6	32.3
Pour, °F.	15	15	10	10	10	10	15	15	15	10	15	10
Viscosity, SUV 100 F.	139	136	129	128	133	134	390	375	520	510	535	515
Color, Lovibond	140	1	80	1	6	1	2	1	6	1	2	1
Viscosity-Gravity Constant	0.822	0.820	0.811	0.810	0.810	0.814	0.796	0.796	0.810	0.811	0.798	0.800

Visualizing Gas-Solid Dynamics In Catalytic Processes

Make use of these "phase diagrams" to help you understand the physical conditions accompanying various directions and degrees of flow

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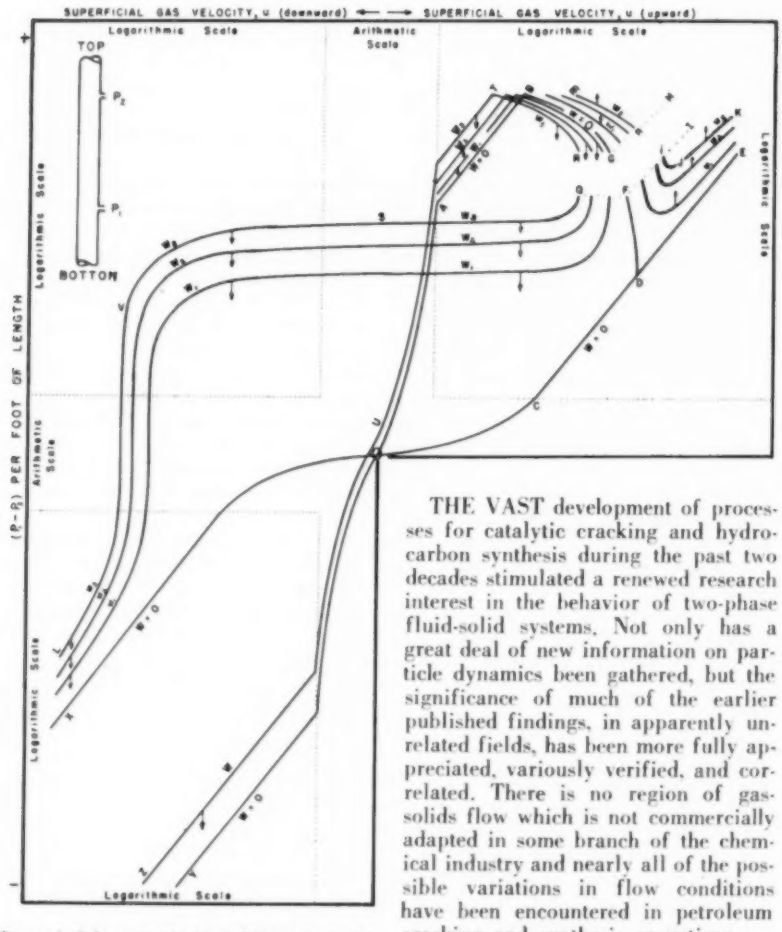

Figure 1. Schematic idealized "phase diagram" for two-phase fluid solid systems in vertical pipe.

THE VAST development of processes for catalytic cracking and hydrocarbon synthesis during the past two decades stimulated a renewed research interest in the behavior of two-phase fluid-solid systems. Not only has a great deal of new information on particle dynamics been gathered, but the significance of much of the earlier published findings, in apparently unrelated fields, has been more fully appreciated, variously verified, and correlated. There is no region of gas-solids flow which is not commercially adapted in some branch of the chemical industry and nearly all of the possible variations in flow conditions have been encountered in petroleum cracking and synthesis operations.

As a means of visualizing the physical condition accompanying various directions and degrees of flow, the construction of so-called "phase diagrams" has been found invaluable.

Graphical Representation of Two-Phase Flow Conditions in Vertical Pipe

Figure 1 presents a somewhat exaggerated idealized phase diagram for gas-catalyst systems in vertical pipes. The ordinate represents pressure drop per unit length of tube with P_1 being the lower and P_2 the upper pressure tap. The abscissa represents superficial gas velocity through the pipe. Note that both ordinate and abscissa pass through the origin. Values of the abscissa to the right of the origin indicate increasing gas velocity up the pipe whereas extending to the left of the origin the abscissa represents increasing gas velocity down through the pipe. At the origin, zero gas velocity implies that no gas is being artificially supplied either to the bottom or top of the pipe. The ordinate from the origin upward represents increasing positive values of the pressure differential P_1-P_2 whereas from the origin downward values of P_1-P_2 become increasingly negative or in other words P_2-P_1 increases. The curves labelled W_1, W_2 and W_3 represent lines of constant mass flow of solids in pounds per unit time per unit pipe cross-sectional area.

This type of plot is generally made most conveniently on logarithmic graph paper which would not permit going through values of zero without a discontinuity in the grid. This is represented in Figure 1 by the dotted vertical and horizontal lines. The arithmetic and logarithmic grids are directly designated in Figure 1. The arrows attached to the curves indicate the direction of motion (upward or downward) of the solid particles; thus the upper right hand quadrant contains regions of cocurrent upward flow and also regions of countercurrent flow, while the upper and lower left hand quadrants represent cocurrent downward flow.

Catalyst-Gas Behavior in Regions of Zero Solids Flow

Consider a vertical pipe containing a fixed bed of uniform size solid particles supported on a grid with gas entering below the grid and passing upward through the tube. The taps, P_1 and P_2, located say a foot apart, somewhere near the middle of the packed height, will record a pressure drop which will be that function of the gas velocity, curve OAB of Figure 1, predictable from the well known fixed bed pressure drop correlations of Chil-

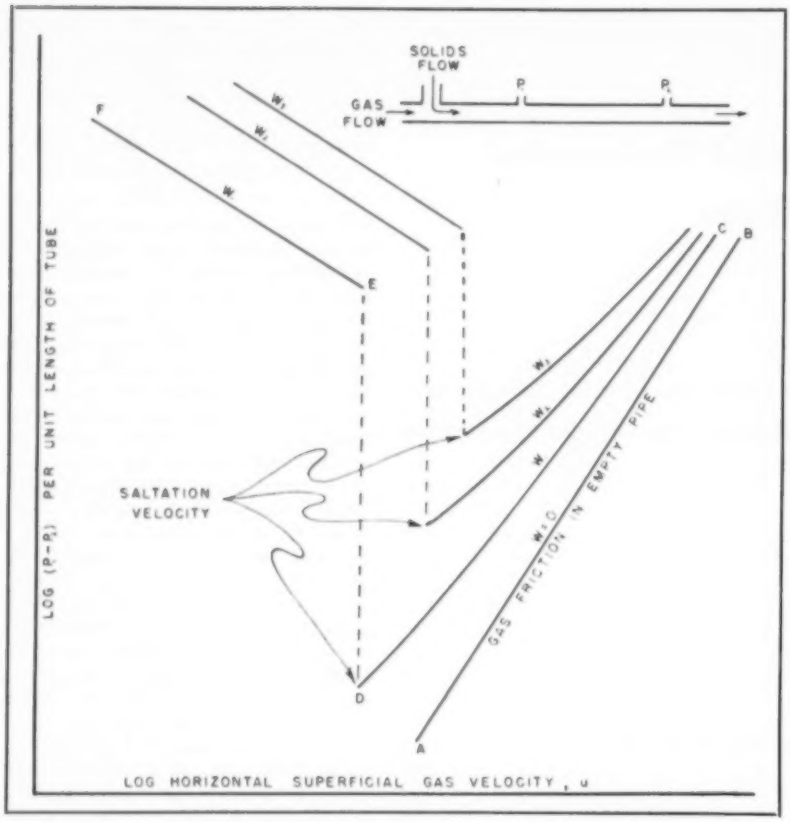

Figure 2. Schematic plot of pressure drop for two-phase fluid-solid flow in horizontal pipe.

ton and Colburn[12] or modifications thereof as presented by Bakhmeteff and Feodoroff,[3] Carman,[11] Oman and Watson,[54] and numerous other workers[10, 14, 15, 17, 32, 42, 47, 48, 55, 58] who have attempted to take into account shape factors and voidage functions. Along the curve OAB there is no net flow of solids between the points P_1 and P_2 and accordingly the curve is labelled W = 0, without arrows.

At point B the pressure drop has reached a value equal to the weight of solids per unit of tube cross section; the solids are being bouyed by the gas stream, exert no weight on the supporting grid, and would hypothetically remain in place if the supporting grid were taken away, were it not for the fact that the variation in velocities in a traverse of the tube cross section would permit particles to slip downward at the tube wall countercurrent to the rising mainstream.[65] The condition at B is referred to in the literature as the point of incipient fluidization. Further increase in gas velocity causes the bed to expand along the curve BG which is the conventional dense phase fluidization curve. Several methods are presented in the literature for calculating curve BG.[24, 44, 45, 64]

As the bed expands, the inventory of solids between taps P_1 and P_2 decreases and therefore the pressure differential per unit length of bed decreases, while the pressure drop across the entire height of bed remains constant. At the point of initial bed expansion small bubbles of gas rise up through the particles. As the gas velocity approaches point G the gas bubbles become larger and larger until at point G they have grown in size equal to the diameter of the tube before escaping from the bed, and thereby create gas pockets pushing short columns of fixed bed solid particles up the tube. These slugs of solids shower down into the rising gas bubbles at the periphery of the tube such that every few seconds a bubble bursts through the top of the bed but there is still no net transport of solids upward or downward through the tube.

If the velocity is further increased beyond point G the solid slugs no longer shower down into the gas bubbles but are carried out of the top of the tube until the inventory becomes so low that the remaining particles are suspended in a uniform dispersion throughout the tube length. This condition is indicated by point F in Figure 1. Further increase in velocity is accompanied by further decrease in solids inventory and more dilute phase fluidization curve. The at point D only one particle remains. The velocity at point D represents the balancing velocity of the particle calculable from drag coefficient correlations. Curve FD is referred to as the dilute phase ffuidization curve. The pressure differential to support the single particle at point D is generally negligible in comparison to the frictional pressure drop between the gas and tube wall so that point D intersects the curve OCDE representing gas friction drop calculated from the Fanning equation for the empty pipe.

Before discussing the development of the solids transport curves it may be well to point out some of the discrepancies between actual observations and the highly idealized presentation so far given in Figure 1. Starting with the calculation of balancing velocities at point D it should be noted that the classical drag coefficient curve[41] is at best only a good approximation. It is based on free fall and sedimentation experiments in quiescent fluid. The velocity at point D is a balancing velocity which is not only a function of the particle and fluid characteristics but also the nature of the fluid flow pattern or degree of turbulence in the fluid stream.

The literature contains considerable information on the effect of artificially induced turbulence on drag coefficients in wind tunnel experiments[23, 25, 30, 50] the differences between balancing velocities and terminal velocities[31, 53] determined for coal particles in water,[36, 49, 52] and sedimentation rates in turbulent streams.[8, 20, 22] The data presented by Friend[28] for a large diameter reactor in which the gas flow was definitely in the turbulent regime (with added turbulence induced by the presence of the fluid bed), (despite the laminar Reynolds number calculated for the particles), are practical evidence of the effect of flow turbulence on the balancing velocity. In addition to turbulence considerations, occurring primarily in large diameter conduits, proper account must also be taken of the Ladenburg[40] correction for wall effect in small tubes where the ratio of particle to tube diameter may become significant. In addition, the height of the tube must be taken into consideration. Less velocity is required to suspend a single particle at the bottom end of a vertical tube than to suspend it near the top; this may at times become an important factor in correlating performance of high vertical transport lines with data from relatively short pilot plant lengths. Due allowances must also be

made when dealing with particles smaller than 0.003 inch in diameter where interparticle forces are sufficient to cause agglomeration and flocculation.[4, 46, 51]

Point F which represents the maximum attainable solids concentration in the dilute phase before the onset of slugging,[7, 68] is also a function of particle characteristics and gas flow conditions. Present theories suggest that maximum attainable dilute phase particle concentrations can be calculated from the minimum tolerable distances between particles before interference occurs between individual flow patterns. This minimum distance corresponds to the length of the wake behind the particle. Similarly point G represents the maximum voidage or lowest attainable dense phase fluid bed density before the onset of slugging conditions. Point G as well as the level of curve BG is a function of the tube diameter, the ratio of bed height to tube diameter, the catalyst particle size and size distribution,[9, 62] and the density of particle and fluidizing gas. Studies are at present under way to determine conditions under which ideal fluidization, representing a smooth non-slugging continuous curve from B to D, might be attainable.[33]

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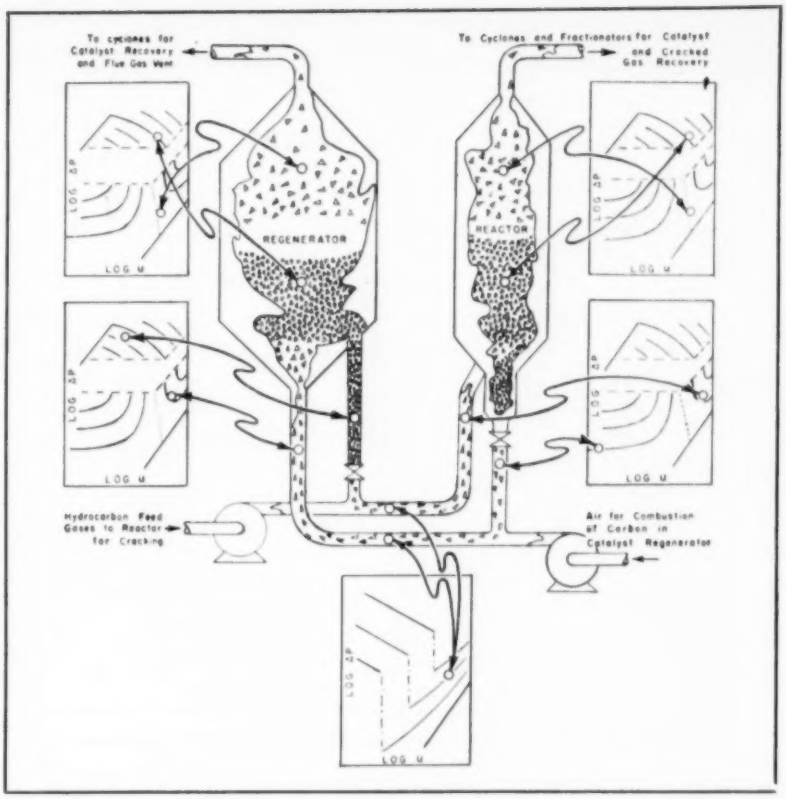
Cocurrent Vertical Gas-Solids Flow

Consider again a vertical tube with gas entering at the bottom and flowing up the tube; the tube is empty with the gas flowing at a velocity of say 100 feet per second. Assume that solids are continuously introduced into the gas stream at the bottom of the pipe at a uniform rate of W_3 pounds per second per square foot of pipe cross section. The particles will travel up the tube in a uniform dispersion at a velocity equal to the superficial gas velocity minus the dilute phase fluidization velocity corresponding to the flowing density, which is essentially equal to the particle balancing velocity at the low concentrations accompanying such high gas rates. The pressure drop per unit length (at distances so far removed from the point of introduction of solids that velocities are constant and particle acceleration is no longer occurring) is equal to the solids concentration in the tube plus the frictional pressure drop for the gas stream. These flow conditions are represented at point K in Figure 1. As the gas velocity is reduced (the solids feed rate W_3 remaining constant) the pressure drop between taps P_1 and P_2 decreases (since gas friction drop exceeds solids head loss) until at some point, such as J, particle velocity has decreased to such an extent that the solids concentration in the tube represents an appreciable head loss. At gas velocities less than that at point J, the head loss required to support the increasing solids inventory rapidly begins to exceed the gas frictional losses, and the over-all pressure differential P_1-P_2 increases as gas velocity decreases.

The region JK of the cocurrent dilute phase transport curves has in recent years been widely investigated and numerous correlations suggested for calculation of over-all pressure loss.[5, 16, 26, 27, 29, 34, 61, 63, 65, 68]

As the gas velocity is further decreased the solids inventory increases until at point i the flowing particles are again at the minimum separation before which interference between flow patterns causes agglomeration. At this point the flowing dispersion in the tube collapses instantly and transport continues in slug flow; the particles introduced at the bottom accumulate into short fixed bed slugs which are carried as a fixed mass up the tube. The relationship between solids flow rate, W, and the minimum or choking gas velocity at point i for dilute phase transport has not received a great deal of academic experimental investigation[16, 68] despite its importance in the design of catalyst transfer lines. Even in the field of pneumatic conveying it is general practice to design safely for velocities far in excess of the choking rate. The locus of choking points indicated in Figure 1 by the dashed line FI is a line of constant voidage for the dispersion, corresponding again to the minimum distance between particles before agglomeration to fixed bed slugs. In large diameter lines where gas friction CDE is very small, FI may


To cyclones for Catalyst Recovery and Flue Gas Vent
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REACTOR
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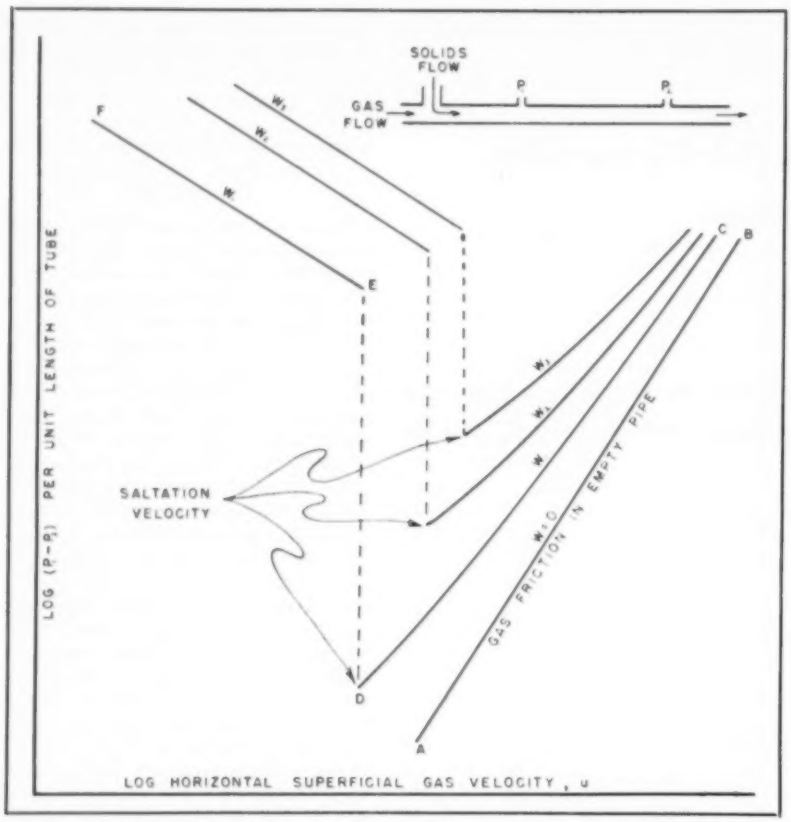
Figure 3. Various regions of the fluid-solid flow diagrams in relation to plant design (Fluid catalytic cracking).



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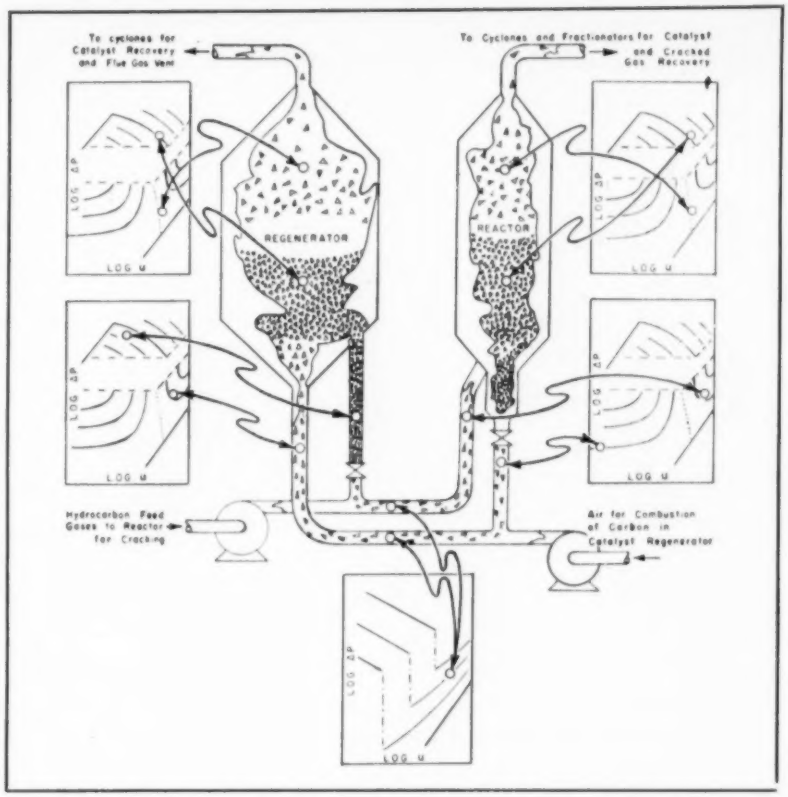
To cyclones for Catalyst Recovery and Flue Gas Vent
To Cyclones and Fractionators for Catalyst and Cracked Gas Recovery
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REACTOR
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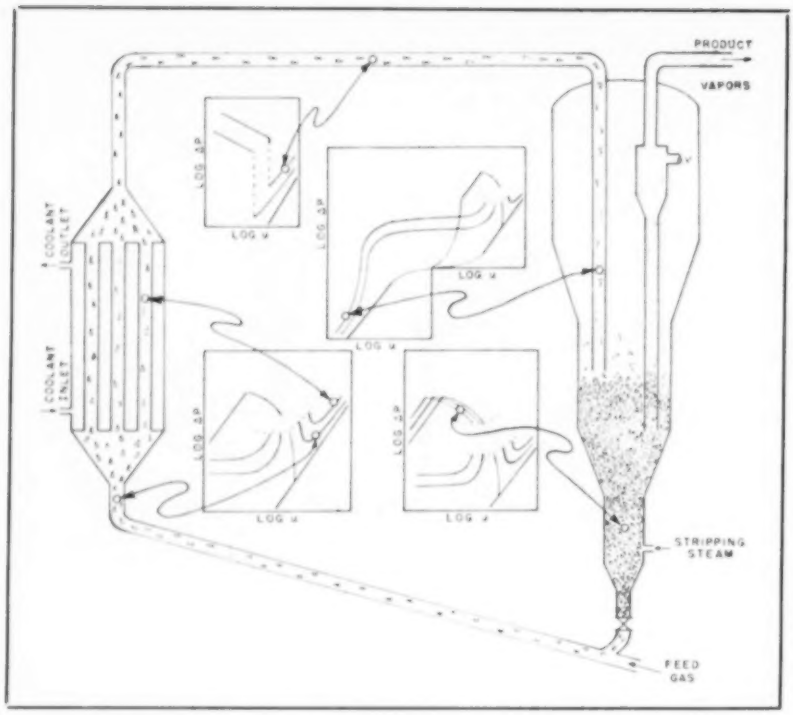

Figure 4. Two-phase flow diagrams in relation to dilute phase transfer line synthesis reactor.

be a nearly horizontal line for quite a distance to the right of point F until gas friction again becomes appreciable.

As the velocity is further decreased, below that at point i, the inventory of slugs increases until at some point, n, the tube is nearly filled with solids, the gas passing up through the mass as bubbles, much the same as in a dense phase fluidized bed, and solids transport, W_3, occurring as spill-over at the top of the tube, replenished by the solids entering at the bottom. Further decrease in gas velocity results in smoother fluidization characteristics within the tube and a less intermittent flow of solids at the upper discharge end. Finally, at point m the solids travel up the tube as a dense phase mass at a velocity merely great enough to carry out within the interstices the gas normally present as bubbles in fluidization. The condition at point m is referred to as "mass flow." The difficulties involved with the required pressures, coupled with the limited number of practical applications for mass flow, have limited experimentation in this region. However, the so-called "hyperflow" lift system reported by Union Oil Company[6] is a recent commercial application with a basis in development work on mass flow.

Further decrease in gas rate, below that at point m, results in decreasing solids throughout rate W, unless mechanical means are introduced into the system to push the solids up the tube.

In the foregoing discussion the rate of solids throughput has been assumed constant, equal to W_3. The effects of changing solids throughput at constant pressure drop or constant gas rate are shown schematically in Figure 1 by the curves W_1, W_2, and W_3 which represent increasing solids flow rates.

Countercurrent Vertical Gas-Solids Flow

Consider again a vertical tube with means for introducing gas at the bottom and solids from a hopper, by gravity flow, at the top. With no gas entering at the bottom of the tube and the hopper set to discharge uniformly W_3 pounds per second per unit cross section into the top of the tube, a pressure drop will be recorded between taps P_1 and P_2 created by the compressive pumping action of the free falling solids dropping down through the tube as a dilute dispersion. This pressure differential is shown as point S at zero gas velocity in Figure 1 and corresponds to the head loss in dilute phase fluidization for the same particle concentration. If a small upward flowing stream of gas, opposing the downward motion of the solids, is introduced at the bottom of the tube only a slight rise in pressure differential will be detected. As the upflowing gas velocity is increased, the downward velocity of the solids (equal to the free fall velocity of the dispersion minus the countercurrent gas velocity) will decrease. The resulting increase in inventory of downflowing particles will register an increase in the differential between taps P_1 and P_2. Finally, when the gas velocity has been increased to the value at point Q in Figure 1, the solids inventory will again correspond to that attained at the minimum interparticle distance before interference occurs between flow fields of individual particles and the uniform dispersion again collapses into slugs. Point Q corresponds to a dilute phase countercurrent "flooding" point. Studies of such flow phenomena as occur along curve SQ have been reported in the literature.[35, 68]

It is also possible to maintain the same solids transport rate, W_3, with a dense phase present in the tube by again reducing the upward gas velocity. Dense phase down transport with countercurrently rising gas bubbles (as occurs in aerated standpipe and seal leg operations) is represented by curve RT. In calculating such transport curves in the region RT, consideration must be taken of the velocity of rise of gas bubbles in the fluid mass. The superficial downward velocity of the solids may not exceed the velocity of rise of the bubbles.[19] As point T is approached, the number and size of the rising gas bubbles decreases until at point T all the gas which passes up through the downwardly moving fixed bed (no longer a fluid bed) finds its way up via the interstices, without creating bubbles. Such are the flow conditions along curve TU occurring in many moving bed reactors or regenerators in TCC, Houdriflow, Hypersorption, and other units. In these processes the downward velocity of the fixed bed is generally so low as to be almost negligible. The pressure drop is essentially calculable from the conventional stationary fixed bed correlations, though specific investigations have been reported for countercurrent movement.[32] As in the cocurrent upward flow region, the effect of variation in solids flow rate is shown in Figure 1 by curves of constant solids mass velocity increasing from W_1 to W_3.

Cocurrent Downward Flow of Gas and Solids in Vertical Pipe

If in the previous illustration the fixed bed moved down through the tube with gas flowing cocurrently from top to bottom, the pressure differential P_1-P_2 becomes smaller and

smaller until at sufficiently high gas rates it becomes negative along a curve such as UZ of Figure 1. The pressure drop in this region of flow commonly encountered in the lower sections of moving bed regenerators, is again calculable from fixed bed correlations.

Consider again the situation in which the particles pass down through a tube in free fall dispersion as along curve QS. If gas is introduced cocurrently at the top of the tube the pipe-to-gas frictional loss begins to create increasing pressure at tap P_2 such that the differential P_1-P_2 becomes smaller along the curve SV. This region of flow has been experimentally investigated by Hettich and Kean[35] and Docarmo.[21] As downward gas velocity is further increased the solids concentration in the tube becomes less and less so that gas friction becomes the major pressure loss and P_2 begins to exceed P_1 along the curve VL.

Horizontal Flow of Gas-Solids Mixtures

Figure 2 presents a schematic plot of pressure drop versus gas velocity for flow of catalyst-gas mixtures in horizontal pipe. Curve AB represents the Fanning frictional loss for flow of gas alone in the empty pipe. Suppose that at the gas velocity at point C (say 100 feet per second) a continuous uniform rate of flow of solids, W_1, be introduced into the gas stream. The dilute catalyst-gas suspension will flow cocurrently along the pipe as in simple pneumatic conveying with an accompanying pressure loss somewhat greater than that for the gas alone. As the gas velocity is reduced the particles will also travel at a slower speed thereby increasing the inventory of solids within the pipe. At point D the solids velocity has decreased to the point where interparticle forces can create disturbances great enough to make it impossible for the energy in the gas stream to overcome the tendency of particles to settle out of the flowing suspension and form a layer in the bottom of the tube. These interparticle disturbances are greater for grinds with a particle size distribution, where particle velocities vary, than for material of uniform particle size. The velocity at point D is therefor greater for mixed size material at the same throughput.[68]

The superficial gas velocity at which particles settle out of a flowing suspension is referred to as the "saltation velocity"[56] and is a function of the solids transport rate W. Experiments at constant solids rate have shown that at the saltation velocity, when particles begin to settle out in the tube, there occurs an unsteady state time lapse during which particles continue to settle out until the horizontal pipe is nearly half full. Steady state uniform flow conditions are then reestablished within the gas-solids suspension flowing in the space above the settled layer of particles. The actual velocity of both gas and solids will now be much greater and the pressure drop between taps P_1 and P_2 will have increased to the value at point E of Figure 2 due to the restriction caused by the settled layer in the lower half of the tube. The particles settled out remain stationary in the tube; there is no rolling of the material or pushing

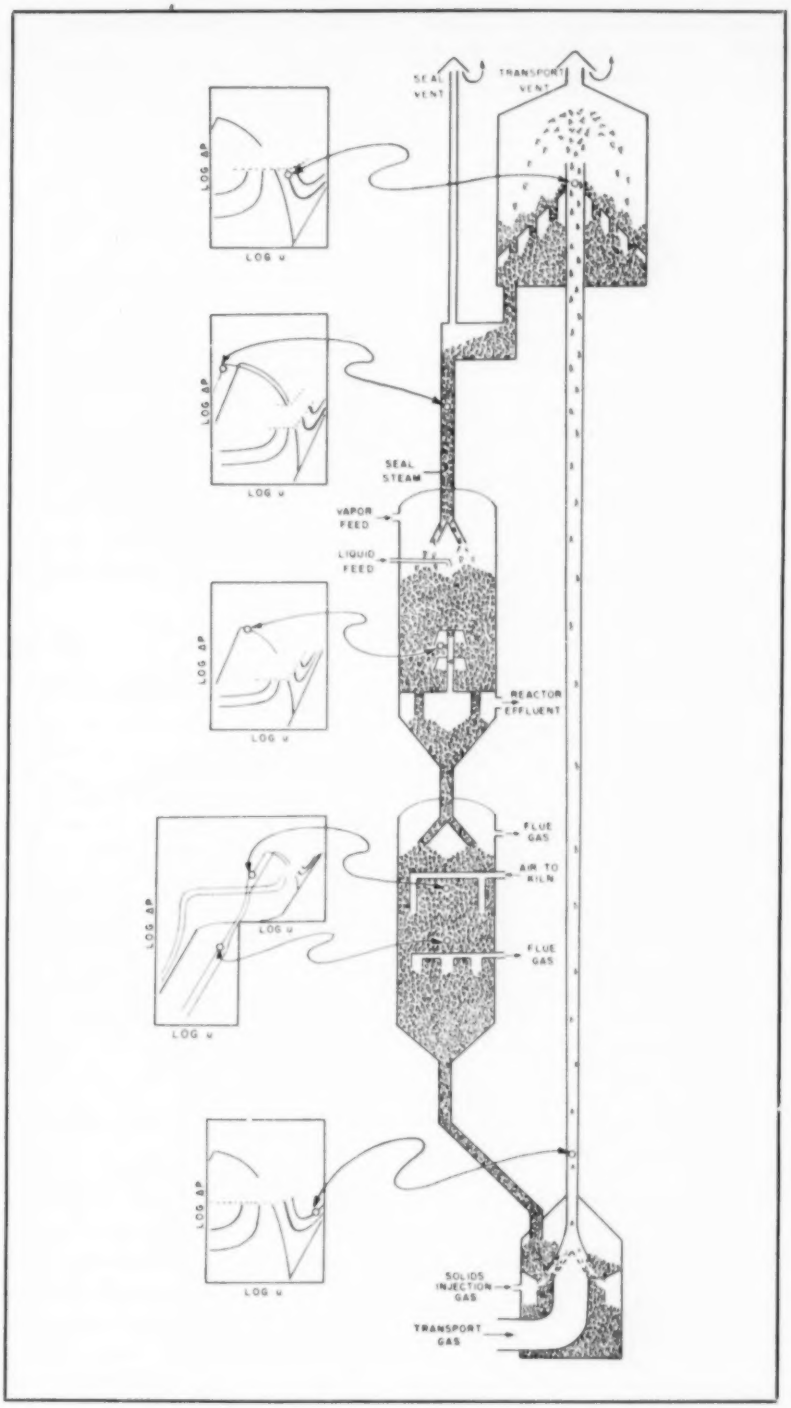

Figure 5. Illustrative two-phase flow regions in the main sections of a moving bed cracking unit.

of the entire layer through the tube, though a few of the particles on the surface of the layer are bounced along in the direction of gas flow. Several experimenters have investigated dilute phase transport along the curve CD,[18,26,27,38,56,57,59,61,66,68] but only recently has there been an experimental interest in determining the relationship between saltation velocity and solids flow rate.[18,68]

When at point E the solids have settled out in the lower half of the tube and steady state disperse phase flow is established in the upper half of the tube, further reduction in gas flow causes more and more particles to settle out, filling the tube with a deeper layer and creating an increase in pressure drop for the flowing suspension, as indicated along curve EF of Figure 2. The entire curve, CDEF, is reproducible in either direction. If at point F the superficial gas velocity is increased then the settled layer of particles becomes less and less deep until at point E there occurs again a lengthier unsteady state period during which the entire layer is slowly swept out of the pipe and disperse phase flow again occurs throughout the entire cross section, as along curve DC. The effect of solids mass flow rate is shown by curves W_1, W_2, and W_3 representing increasing particle transport rates. It should be noted that the high ratios of solid to gas loading obtained along curve EF may easily lead to the erroneous conclusion that the flow occurs as a moving dense phase or fluidized mass, in view of the low superficial gas velocities. However, experiments in $\frac{3}{8}$-inch lucite tubing with microspheroidal catalyst[67] as well as in larger lucite and iron pipes with a variety of solids, have shown saltation phenomena to take place.

Koble[39] reported experiments in $\frac{1}{4}$ to $\frac{3}{8}$-inch copper tubing where observation was limited to the discharge end of the tubes. He realized the possibility that saltation may have been present and attempted to determine if such was the case. The tests, in his own words, were "inconclusive." Judging from the nature of the data reported in the paper by Albright et al.[1] their data were also obtained in the saltation region, as evidenced by plotting their pressure drop curves which parallel the situation schematically indicated by curve EF of Figure 2. In small tubes at very low gas rates the solids eventually flow through the tube as half-round slugs above the stationary layer of settled particles.[67]

Two-Phase Flow Diagrams

Figure 3 represents a schematic sketch of the original two-vessel fluid cracker designs. Beside the vessels are shown four schematic illustrations of the flow diagrams outlined in Figures 1 and 2. Arrows identify the flow characteristics at various points in the process with the corresponding regions on the flow diagrams.

Figure 4 represents The M. W. Kellogg Company's recently developed dilute phase transport reaction scheme for conducting hydrocarbon synthesis from hydrogen and CO.[37] Only one coolant vessel is indicated whereas in practice several such vessels would be installed in series for close temperature control along the entire reaction path. The trend to dilute phase gas solid contacting is evidenced also in the petroleum cracking field. Several major companies are experimenting with transport crackers and recently Humble Oil & Refining Company successfully put a "transfer line reactor" into commercial operation.[2] The petroleum industry which was mainly responsible for the development of fluidized solids operations now appears to be leaving this technique in favor of moving bed and dilute phase contacting.

Figure 5 is a schematic representation of typical moving bed cracking units such as Houdriflow and TCC which differ processwise mainly in the use of kiln flue gas or air respectively for the lift leg transport medium. Though nearly all phases of gas-solids flow occur in any of the processes outlined here, the conditions in the main reaction zones are different. In Figure 3 reaction occurs in a dense phase fluid bed, in Figure 4 in dilute phase transport, and in Figure 5 in a slowly descending fixed bed.

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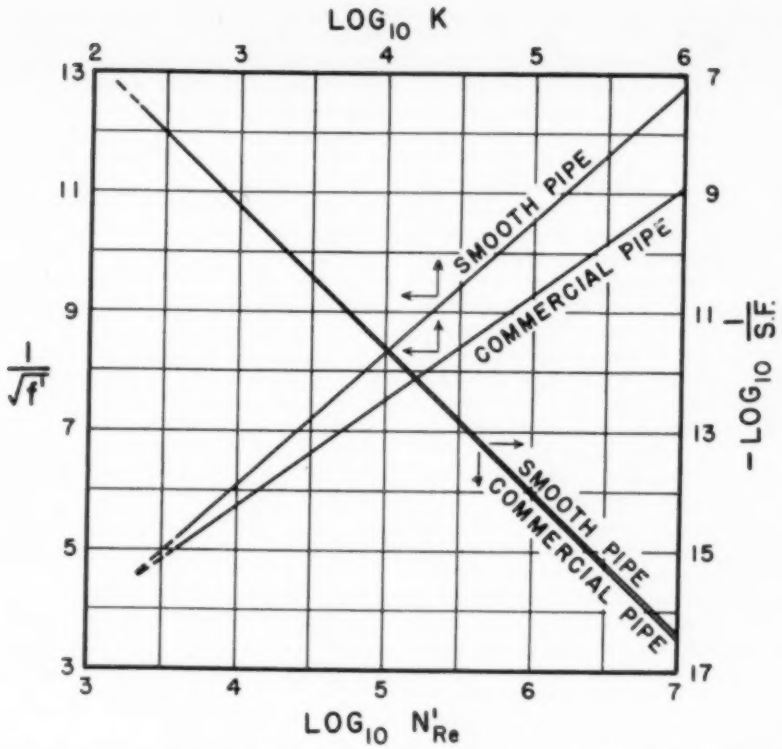

Figure 1. A chart which can be used for direct solution of problems in fluid flow, turbulent conditions. Bonilla.[1] (Reproduced in part through the courtesy of the author and the American Chemical Society.)

Learning How to Use Dimensional Analysis

I. Which dimensional system should you use?

II. The correct use of dimensional systems.

III. The Rayleigh Method.

IV. The Buckingham Pi Theorem.

I. H. Silberberg* and J. J. McKetta, Jr.**

THIS SECOND METHOD of dimensional analysis was introduced by Edgar Buckingham in 1914.[4] *** Because of Buckingham's use of the symbol π for a dimensionless group, the name "Pi Theorem" has become attached to the method. Actually, Buckingham did not present a rigorous proof of his theorem, nor did Bridgman[2] Eshbach,[5] or Van Driest,[17] although all presented excellent arguments in support of its validity. However, Langhaar[7] has recently presented a rigorous proof of the Pi Theorem which takes into account all of the apparent exceptions to the theorem that have plagued the other workers in the field. No attempt will be made here to demonstrate the proof of the Pi Theorem. Instead, the equations which are involved in the method will be shown, thereby demonstrating the workings of the method.

Langhaar[7] has pointed out the *sufficiency* of the condition that, in order for an equation to be dimensionally homogeneous, it must be reducible to an equation involving dimensionless groups (products). The proof of the Pi Theorem requires that this condition also be proved a *necessary* one. Langhaar has therefore stated the Pi Theorem as follows:

> "If an equation is dimensionally homogenous, it can be reduced to a relationship among a complete set of dimensionless products."

Langhaar has defined a complete set of dimensionless products as follows:

> "A set of dimensionless products of given variables is complete if each product in the set is independent of the others, and every other dimensionless product of the variables is a product of powers of dimensionless products in the set."

Langhaar's rigorous proof of the Pi Theorem has also justified the use of the general functional form employed with Rayleigh's method; no matter how the set of dimensionless groups is obtained, so long as that set is *complete* for the quantities being considered, any relation between these dimensionless groups may be a valid representation of the phenomenon being described.

The dependence of n quantities may be expressed in the form of

$$Q_1^{a_{i1}} Q_2^{a_{i2}} Q_3^{a_{i3}} \ldots Q_m^{a_{im}} \ldots Q_n^{a_{in}} = \pi_i, \quad i = 1, 2, 3, \ldots, p \qquad (1)$$

The significance of m and p will be explained shortly. No dimensionless constant is needed in Equation (1). In the Rayleigh method,**** the *minimum* number of dimensionless groups possible from n quantities described by r dimensions was $n - r$. In the Buckingham method, it is necessary to know beforehand how many dimensionless groups will constitute a complete set. Consequently, the symbol m is introduced and defined as the number of *restrictions* placed upon Equation (1) by virtue of the requirement of dimensional homogeneity. Furthermore, m will have as its *maximum* value the number of primary dimensions r. If there are m restrictions on the values of a_1, a_2, a_3, ..., a_n in Equation (1), there will be $n - m$ unrestricted exponents, and consequently $n - m$ dimensionless groups

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*** All reference numbers refer to the list of "Literature Cited" at the end of Part III of this series.

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will result. Langhaar[7] has proved that the number of dimensionless groups p constituting a complete set for n quantities is given by the equation

$$p = n - m \qquad (2)$$

According to Buckingham's theorem, the p dimensionless groups π_1, π_2, π_3, ..., π_p are then related by the general functional equation

$$\phi(\pi_1, \pi_2, \pi_3, \ldots\ldots, \pi_p) = 0 \qquad (3)$$

This equation does no more than state that the particular phenomenon may now be described as rigorously and accurately in terms of the complete set of p dimensionless groups as it might be described in terms of the n quantities involved in the phenomenon.

The evaluation of m has been the chief difficulty in the use of the Buckingham method. Van Driest[17] stated that m could be considered as the maximum number of quantities involved in the problem that could be combined *without* forming a dimensionless group. Langhaar[7] has rigorously proved this to be true and has further shown that m is in reality the rank of the matrix formed from the exponents of the dimensions of the quantities. This use of matrices in connection with Buckingham's method is convenient but is by no means essential to the method. The determination of m as the maximum number of variables which will not combine to form a dimensionless group is entirely satisfactory although sometimes rather tedious. A simple demonstration of the fact that the maximum value of m is the number of primary dimensions results from a consideration of the five variables force, mass, length, time, and temperature with engineering-system dimensions. Obviously these five variables cannot possibly form a dimensionless group, but the inclusion of any other variable describable by the dimensions F, M, L, Θ, and T will permit the formation of a dimensionless group.

Since there are by definition m restrictions upon the values of the constant exponents a_1, a_2, a_3, ..., a_m, ..., a_n in Equation (1), let the constants a_1, a_2, a_3, ..., a_m be those so restricted. The constants a_{m+1}, a_{m+2}, ... a_n may be assigned any value, as they represent the $n - m$ unrestricted constants. To determine π_1 ($i = 1$) from Equation (1), let $a_{m+1} = 1$ and a_{m+2}, a_{m+3}, ..., a_n all equal zero. Similarly, to determine π_2 ($i = 2$), let $a_{m+2} = 1$ and a_{m+1}, a_{m+3}, ..., a_n all equal zero. If this procedure is followed for all of the $n - m$ unrestricted constants, the following set of equations will result:

$$\begin{aligned}
\pi_1 &= Q_1^{a_1} Q_2^{a_2} Q_3^{a_3} \ldots\ldots Q_m^{a_m} Q_{m+1} \\
\pi_2 &= Q_1^{a_1} Q_2^{a_2} Q_3^{a_3} \ldots\ldots Q_m^{a_m} Q_{m+2} \\
&\vdots \\
\pi_p &= Q_1^{a_1} Q_2^{a_2} Q_3^{a_3} \ldots\ldots Q_m^{a_m} Q_n
\end{aligned} \qquad (4)$$

This set of equations represents the equations that must be constructed from the quantities in any problem when Buckingham's method is used. The same m quantities appear in all p equations. In order to avoid difficulty or a complete impasse in the solutions of these equations, it is *essential* that these m repeating quantities be such that they alone are not capable of forming a dimensionless group.

Example 1

Heat Transfer Film Coefficient

It is desired to determine a complete set of dimensionless groups with which to correlate experimental data on the film coefficient of heat transfer between the walls of a straight conduit with circular cross-section and a fluid flowing in that conduit. The variables and the dimensional constant believed to be involved and their dimensions in the engineering system[16] are given below.

Film coefficient = h (F/LΘT)
Conduit internal diameter = D (L)
Fluid linear velocity = V (L/Θ)
Fluid density = ρ (M/L^3)
Fluid absolute viscosity = μ (M/LΘ)
Fluid thermal conductivity = k (F/ΘT)
Fluid specific heat = c_p (FL/MT)
Dimensional constant = g_c (ML/FΘ^2)

The first step in the solution requires the determination of m. Since there are 5 primary dimensions (FMLΘT) involved, the maximum value that m might have is 5. A few trials will show that there are several sets of 5 quantities which do not form dimensionless groups, but all such sets contain the dimensional constant g_c. The significance of this fact will be discussed later. Since m therefore has the value 5, the $n = 8$ quantities listed above should produce a complete set of $p = n - m = 3$ dimensionless groups according to Equation (2).

Let the 5 repeating quantities which do not form a dimensionless group be D, V, μ, k, and g_c. According to Equation (4), the following equations represent the three dimensionless groups:

$$\pi_1 = D^{a_1} V^{b_1} \mu^{d_1} k^{e_1} g_c^{f_1} h \qquad (5)$$
$$\pi_2 = D^{a_2} V^{b_2} \mu^{d_2} k^{e_2} g_c^{f_2} c_p \qquad (6)$$
$$\pi_3 = D^{a_3} V^{b_3} \mu^{d_3} k^{e_3} g_c^{f_3} \rho \qquad (7)$$

In these equations, h was included with the 5 repeating variables to form π_1. Similarly, c_p was included to form π_2, and ρ was included to form π_3.

The procedure from this point is identical to that in the Rayleigh method, with the exception that no undetermined exponents will be found, as the number of restrictions on each equation and the number of exponents are the same. This is a general characteristic of the Buckingham method. The dimensional equation corresponding to Equation (5) is

$$F^0M^0L^0\Theta^0T^0 = (L)^{a_1}(L/\Theta)^{b_1}(M/L\Theta)^{d_1} (F/\Theta T)^{e_1}(ML/F\Theta^2)^{f_1}(F/L\Theta T) \qquad (5a)$$

Applying the condition of dimensional homogeneity:

$$\begin{aligned}
\Sigma F = 0:&\ 0 = e - f + 1 \\
\Sigma M = 0:&\ 0 = d + f \\
\Sigma L = 0:&\ 0 = a + b - d + f - 1 \\
\Sigma \Theta = 0:&\ 0 = -b - d - e - 2f - 1 \\
\Sigma T = 0:&\ 0 = -e - 1
\end{aligned} \qquad (5b)$$

The solutions to Equations (5b) are

$$\begin{aligned}
a &= 1 \\
b &= 0 \\
d &= 0 \\
e &= -1 \\
f &= 0
\end{aligned} \qquad (5c)$$

Equation (5) then becomes

$$\pi_1 = D^1 V^0 \mu^0 k^{-1} g_c^0 h$$
$$\pi_1 = \frac{hD}{k} \qquad (5d)$$

In a similar manner, the solutions to Equations (6) and (7) are found to be

$$\pi_2 = \frac{c_p \mu}{k} \qquad (6d)$$

$$\pi_3 = \frac{DV\rho}{\mu} \qquad (7d)$$

The dimensionless group hD/k is called the Nusselt number, N_{Nu}, and the group $c_p\mu/k$ is the Prandtl number, N_{Pr}. The group $DV\rho/\mu$ is the familiar Reynolds number, N_{Re}, encountered in fluid friction problems. These three dimensionless groups are frequently used in heat transfer film coefficient correlations. Functionally, their relation may be expressed as

$$\phi(N_{Nu}, N_{Pr}, N_{Re}) = 0 \qquad (8)$$

or as

$$N_{Nu} = \phi_1(N_{Pr}, N_{Re}) \qquad (8a)$$

It has been found that these dimensionless groups may be correlated well by an equation of the type

$$\frac{hD}{k} = K\,(c_p\mu/k)^a (DV\rho/\mu)^b \qquad (8b)$$

in which K, a, and b are experimentally determined dimensionless constants. However, any other type of algebraic expression or perhaps simply a graphical relation among these three groups that accurately fits the experimental data would be an equally valid manner of expressing Equation (8).

Other Groups

Naturally, other dimensionless groups might have been obtained in Example 1 by employing a different set of 5 repeating quantities that would not form a dimensionless group among themselves. Some of these groups may be found among those presented in Table I. Such a complete set of 3 dimensionless groups might

consist of the Stanton, Reynolds, and Prandtl numbers, or of the Stanton, Peclet, and Prandtl numbers. Also, such a complete set different from that obtained in Example 1 will result from a multiplication of appropriate powers of the Nusselt, Prandtl, and Reynolds numbers. For such a set to be complete, however, it must satisfy the condition that each of the 3 dimensionless groups be independent of the other two.

Although it is not directly necessary to know in the Buckingham method how many quantities are really involved (dimensionally combinable) in the problem, it is essential to the method that the correct estimation of the value of m be made. Since the inclusion of a quantity that is not dimensionally combinable will increase the value of m, thereby increasing the number of repeating quantities in the equations of the type of Equations (4), some difficulty might conceivably arise. When a small number of quantities are involved, a dimensionally non-combinable one will *usually* become conspicuous upon inspection of the dimensions of the quantities. When a large number of quantities are involved, such a determination by inspection may be difficult or even impossible. However, when dealing with a large number of quantities, it is *unlikely* that more than one of these quantities would be dimensionally non-combinable without being obviously so. The discussion here will consequently be limited to such a case in which only one of the quantities is dimensionally non-combinable.

If a quantity is dimensionally non-combinable, it would certainly be included in the largest sets of quantities characterized by an inability to form a dimensionless group among themselves. Since no such set is possible without the inclusion of this non-combinable quantity, the value of m deduced thereby is greater by one than that value which would be deduced if this non-combinable quantity were not considered at all. In such a case, when the equations of the type of Equations (4) are constructed, this quantity is included among the m repeating quantities but, being non-combinable, drops out from each dimensionless group being formed. This was the case with g_c in Example 1. Since both n and m are increased by one as a result of the inclusion of this non-combinable quantity, neither the prediction of the number of dimensionless groups nor the results of the analysis are affected in any way.

TABLE 1

Dimensionless Groups in the Engineering System of Dimensions,* [10, 12]

Biot number	N_{Bi}	hL/k
Condensation number	N_{Co}	$(h/k)(\mu^2/\rho^2 g)^{1/3}$
Number used in condensation of vapors	N_{Cv}	$L^3\rho^2 g_c \lambda / k_g \Delta t$
Euler number	N_{Eu}	$g_c(-dp)/\rho V^2$
Fourier number	N_{Fo}	$k\Theta/\rho cL^2$
Froude number	N_{Fr}	V^2/Lg
Graetz number	N_{Gz}	wc/kL
Grashof number	N_{Gr}	$L^3\rho^2 g_c \beta g \Delta t/\mu^2$
Mach number	N_{Ma}	V/V_s
Nusselt number	N_{Nu}	hD/k
Peclet number	N_{Pe}	$DV\rho c/k$
Prandtl number	N_{Pr}	c_p/k
Reynolds number	N_{Re}	$DV\rho/\mu$
Schmidt number	N_{Sc}	$\mu/\rho D_v$
Stanton number	N_{St}	$h/cV\rho$
Weber number	N_{We}	$LV^2\rho/\sigma g_c$

* Nomenclature defined by Perry et al. (12)

It is impossible to construct a largest set of quantities which do not form a dimensionless group among themselves without inculuding this dimensionally non-combinable quantity. The problem is consequently handled automatically by the determination of m as the largest number of quantities which are not capable of forming a dimensionless group and by the use of this set of quantities as the m repeating quantities in Equations (4). Similarly, no difficulties arise when Langhaar's method employing matrices is used.[7]

By virtue of the inclusion of dimensionally non-combinable g_c in Example 1, the value of m resulting was the maximum value, the same as the number of primary dimensions (FML$^\Theta$T). Had g_c been omitted, an omission which the results of the analysis justified, the value of m would have been 4, one less than the number of primary dimensions. Inspection of Equations (5b) for ΣF and ΣT shows that, if f is assigned the value of zero (equivalent to omission of g_c), these two equations become identical. Furthermore, inspection of the dimensions of the quantities excluding g_c shows that F/T is in reality a primary dimension for that set of variables. In other words, a four-dimensional system (F/T, M, L, Θ) is adequate for the problem. As was pointed out in an earlier paper,[13] dimensions need not have physical significance, so that F/T is a perfectly permissible primary dimension for this problem, and actually the value of m was the number of primary dimensions. It would be misleading, however, not to stress the fact that all cases in which m is apparently less than the number of primary dimensions may not be so explained. The 4 quantities, g_c, $-dp/\rho$, and V as defined for fluid friction are described in the engineering system by the 4 dimensions F, M, L, and Θ. However, $m = 3$ for this case, as these 4 quantities do combine to form the Euler number.

In recent years, dimensional analysis has been used a great deal in work on the problem of power requirement for mixing and agitation. Example 2 shows how O'Connell and Mack[11] have employed dimensionless groups in such a correlation.

Example 2

Power Characteristics of Simple Turbines[11]

When simple turbines (rectangular blades) are used in mixing, the following variables are involved:

Power requirement = P (FL/Θ)
Shaft speed = N (1/Θ)
Blade length = L (L)
Blade width = W (L)
Liquid density = ρ (M/L^3)
Liquid absolute viscosity = μ (M/LΘ)
Dimensional constant = g_c (ML/FΘ^2)

In addition, the number of blades S, although dimensionless, is nonetheless a variable to be considered. For any correlation with power to be successful, since power is the only variable containing the dimension F, it is necessary to include the dimensional constant g_c among the quantities listed.

Under fully-baffled turbulent conditions, viscosity is not a variable. Consequently, the quantities to be considered in the analysis are P, N, L, W, ρ, and g_c; therefore, $n = 6$. The variable S, being dimensionless, does not enter into the analysis. Since 4 dimensions are required (FML$^\Theta$), the maximum value of m is 4. The greatest number of quantities which can be combined without forming a dimensionless group is also 4; therefore, m has its maximum value of 4. The number of dimensionless groups to be expected is $p = n - m = 2$. If P, N, L, and g_c are selected as the 4 repeating quantities for Equations (4), the following two dimensionless groups result:

$$\pi_1 = \frac{Pg_c}{N^3L^5\rho} \tag{9a}$$

$$\pi_2 = \frac{W}{L} \tag{9b}$$

In addition, the number of blades S must also be considered. The general form of the solution then is

$$\Theta[Pg_c/N^3L^5\rho, W/L, S] = 0 \tag{10}$$

O'Connell and Mack[11] found that the following equation gave a good representation of their data taken under fully-baffled turbulent conditions:

$$\frac{Pg_c}{N^3L^5\rho} = (9.74S^{0.405})(W/L)^{1.328}\left(\frac{\mu}{\rho}\right)^{-0.198} \tag{10a}$$

Under viscous conditions, all of the quantities tabulated above enter into the problem. Again, however, m has the value of 4, but n has the value of 7; therefore three dimensionless groups are to be expected. If P, N, L, and ρ are selected as the 4 repeating variables, the following three dimension-

less groups result:

$$\pi_1 = \frac{Pg_c}{N^2L^5\rho} \quad (11a)$$

$$\pi_2 = \frac{\mu}{NL^2\rho} \quad (11b)$$

$$\pi_3 = \frac{W}{L} \quad (11c)$$

The general form of the solution, including the number of blades, is the following:

$$\Theta[Pg_c/N^2L^5\rho, \mu/NL^2\rho, W/L, S] = 0 \quad (12)$$

O'Connell and Mack[11] found that the following equation gave a good representation of their data taken under viscous conditions:

$$\frac{Pg_c}{N^2L^5\rho} = (90.0S^{0.327})(\mu/NL^2\rho)\,(W/L)^{0.635S^{-0.205}} \quad (12a)$$

Application of Dimensional Analysis

Analysis of the Problem

Of primary importance is the selection of the variables and dimensional constants involved in the problem. If an important variable is omitted, solution may be impossible when only a small number of quantities are involved, or the results will be virtually meaningless in cases for which solution is still possible. In addition to a dimensional constant which might be required by the particular dimensonal system, such as g_c, other dimensional constants may enter into the problem, such as the velocity of light, the velocity of sound, the Boltzman constant, etc. Murphy[10] has listed many of these important dimensional constants. As a general rule, however, the investigator possesses such a background of physical experience that he knows (or should know) almost instinctively the nature of the problem with which he is concerned. He is often aware of such laws as may apply and is capable of recognizing immediately *most* of the quantities which are involved. He may make some mistakes, but it is highly unlikely that he will go completely astray. It is usually preferable to start with a differential equation, exact or approximate, which describes the particular phenomenon; even an extremely approximate differential equation may be of considerable help in making the proper selection of variables and dimensional constants. Klinkenberg and Mooy[6] have applied dimensional analysis to a number of differential equations. It must be remembered, however, that the dimensional analysis alone will not tell which quantities are actually involved in the problem. If a variable is "rejected" by the analysis, the only correct interpretation is merely that the variable is non-combinable with the other quantities. The omission of a quantity which is truly involved might be the cause of such a rejection. For example, omission of g_c in the fluid friction problem* would have resulted in the rejection of $-dp_f$, an obviously ridiculous situation. On the other hand, if *all* of the quantities involved have been included and a variable or dimensional constant is rejected by the analysis, then that variable or dimensional constant is truly not relevant to the problem.

In an earlier article,[15] the point was made that any dimensional system, so long as it is capable of describing the quantities to be dimensionally analyzed, may be employed. Usually, it is most convenient to employ one of the three conventional systems, the absolute, the gravitational, or the engineering system. Care must always be taken that the dimensional system subsequently used with the dimensionless groups is consistent with that employed in determining these groups by the dimensional analysis. If F/T had been considered as a primary dimension in Example 1 (with g_c omitted), the engineering system of dimensions would still have been applicable to the resulting dimensionless groups. On the other hand, the Euler number in either the absolute or gravitational system is $-dp/\rho V^2$, but this number would not be dimensionless in the engineering system, which requires the insertion of g_c in the numerator.

Either the Rayleigh or Buckingham method may be used for the actual analysis with the same results. The Rayleigh method has the advantage of not requiring a prior determination of the number of dimensionless groups constituting a complete set, but on the other hand it has the disadvantage of requiring, when a large number of quantities is involved, the solution of a set of long and unwieldy equations. Errors are easily made. The Buckingham method, once the value of m has been determined, involves much less tedious solutions of the sets of equations, although of course there is one set for each dimensionless group. The determination of m is the only real obstacle in the use of the Buckingham method. Often the p dimensionless groups constituting a complete set may be written by inspection of the n quantities, once the value of m has been found. Langhaar's matrix method for determining m is infallible and highly recommended.[7]

It is immaterial what dimensionless groups result from the analysis. Other complete sets may be obtained from the original complete set by multiplication of appropriate powers of the groups. One set may be better suited for correlation from the standpoint of the experimental work, whereas another set may constitute a more convenient correlation from the standpoint of application. The following discussion should make these remarks more apparent.

Experimental Correlation

Several considerations enter into the choice of the complete set of dimensionless groups to be employed in the experimental data correlation. If the true benefit is to be derived from dimensional analysis, i.e., decreasing the number of quantities to be correlated and hence to be varied in the experimental work, it is desirable to employ such dimensionless groups as may be varied easily and over a wide range. The Reynolds number $DV\rho/\mu$ will serve as an excellent example. The numerical value of this group may be varied by changing all four variables contained in it. In a pressure-drop study, ten different pipe sizes might be used, with ten different fluids all possessing different kinematic viscosities (μ/ρ) flowing at ten different velocities. On the other hand, velocity is an easy variable to change, whereas change of pipe size or of fluid requires conversion of the experimental apparatus. It would be much simpler, for example, to use four pipe sizes and four different fluids, both covering the same ranges as when ten of each were used, and to vary the Reynolds number over a wide range of varying the velocity. In the former case, 100 combinations of pipe sizes and fluids would be involved; in the latter, only 16 would be required.

Another factor for consideration is the accuracy with which certain of the variables may be measured. If the value of one variable may be determined only approximately, for the purposes both of correlation of the experimental data and of application of the results that variable should appear in only one dimensionless group. Again an example may be taken from the frictional pressure drop correlation in fluid flow. The dimensionless groups $\varepsilon V\rho/\mu$, the roughness factor, and the Euler number constitute a complete set. The roughness ε, however, is a variable which is difficult to determine accurately. Consequently, two of the three groups would reflect the uncertainties in the values of ε, making a good correlation of the data difficult. It is far better to isolate ε in only one group, ε/D.

In some cases, it may be found

* "Learning How to Use Dimensional Analysis. III. The Rayleigh Method." *Petroleum Refiner*, **32**, 101-3 (June, 1953).

that, of the several complete sets of dimensionless groups possible, one particular set gives a better correlation than any of the others. The correlation of such a set might be superior because better inter-agreement of the individual data points results or because the data plot linearly on logarithmic paper, thereby permitting a representation of the final results as an algebraic expression similar to the numerous heat transfer film coefficient equations now in use. Aside from the considerations previously mentioned, such a situation cannot very well be predicted beforehand, and the selection of the "best" complete set of dimensionless groups must generally be a trial-and-error proposition.

If an important quantity is omitted in the dimensional analysis, correlation of the experimental data will be poor and perhaps no correlation at all will result, for one important dimensionless group will be missing. The same difficulties might arise from the inclusion of a quantity that is not relevant to the study. In the latter case, if the investigator has an inkling of the trouble-making quantity, it may be isolated in one dimensionless group by manipulation of the groups in the complete set. Experimental verification should then follow from a study of the effect of that particular group on the correlation.

The experimental data should be obtained with the dimensionless groups more in mind than the individual variables. Theoretically, the resulting correlation should apply over the experimental ranges of these dimensionless groups. Practically, however, the values of each variable should cover as wide a range as possible; otherwise, the omission of a variable might conceivably slip by unnoticed. Actually, not all true variables are measurable or even recognized, so it is not uncommon to see a correlation that might on the surface be considered general restricted in application to a particular situation or type of system.

Elimination of Trial-and-Error Calculations

When the correlation of dimensionless groups results in a completely algebraic expression such as Equations (8b), (10a), and (12a), any variable in such an equation may be expressed explicitly in terms of the other quantities. However, when the correlation is partly or entirely graphical, an explicit solution for any of the variables is not always possible. For example, in fluid friction correlations using the friction-factor chart, solution for V is not possible, since the friction factor f depends upon V in the form of $DV\rho/\mu$. In such cases, trial-and-error calculations are necessary. The theory of dimensional analysis, however, states that *any* complete set of dimensionless groups is capable of giving a valid representation of the phenomenon being described. If then it is possible, by manipulation of the dimensionless groups in the original complete set, to produce another complete set in which the desired variable appears in only one dimensionless group, the tedious trial-and-error solution may be obviated.

Bonilla[1] has applied this technique to pressure drop in fluid flow. The following "new" dimensionless groups, in which w is the mass flow rate, result:*

Modified Reynolds number $= N'_{Re}$

$$N'_{Re} = \frac{w}{D\mu} \quad (\text{No } \rho \text{ or } -dp_f/dL \text{ involved}) \qquad (23)$$

Modified friction factor $= f'$

$$f' = \frac{(-dp_f/dL)g_c\rho D^5}{w^2} \quad (\text{No } \mu) \qquad (24)$$

von Karman number $= K = N'_{Re}(f')^{1/2}$

$$K = \frac{[(-dp_f/dL)g_c\rho D^3]^{1/2}}{\mu} \quad (\text{No w}) \qquad (25)$$

Size Factor $= S.F. = (N'_{Re})^{5/2}(f')^{1/2}$

$$S.F. = \left[\frac{(-dp_f/dL)g_c\rho w^2}{\mu^{5/2}}\right]^{1/2} \quad (\text{No D}) \qquad (26)$$

In the correlation involving these dimensionless groups, the roughness factor ε/D has been omitted. The engineering system of dimensions is used. The equations above apply to flow in pipes of circular cross-section; the modifications of the Reynolds number and friction factor are based on the fact that the cross-sectional area is proportional to D^2. Since it has been found that the Euler number varies directly with the group dL/D, these two groups may be combined for the purposes of correlation into one group, which may be called the friction factor f. If the reduction of a complete set of three dimensionless groups to one of only two groups is disturbing, the same result may be obtained by considering the pressure gradient in the direction of flow, $-dp_f/dL$, as a single variable.

Figure 1 is Bonilla's chart showing $1/\sqrt{f'}$ plotted against K and 1/S.F. plotted against N'_{Re}. Each of these two pairs represents a complete set of dimensionless groups for the variables involved, ε/D having been excluded. If the pressure gradient, pipe diameter, and fluid properties are known, K may be calculated and w determined from the corresponding value of $1/\sqrt{f'}$. If the pressure gradient, mass flow rate, and fluid properties are known, 1/S.F. may be calculated and the required pipe diameter determined from N'_{Re}. As a more unusual application, it is possible to determine the fluid viscosity directly when the other quantities are known by using the plot of $1/\sqrt{f'}$ vs. K.

Van Driest,[17] through a somewhat different approach, has presented a correlation which permits a direct determination of the flow rate in a pipe when the pressure drop is known. This correlation incorporates the roughness factor ε/D. By means of a similar manipulation of the dimensionless groups to produce a different complete set, Van Driest has also presented for Venturi meters a chart which permits the direct determination either of the discharge from the pressure drop of or the pressure drop from the discharge.

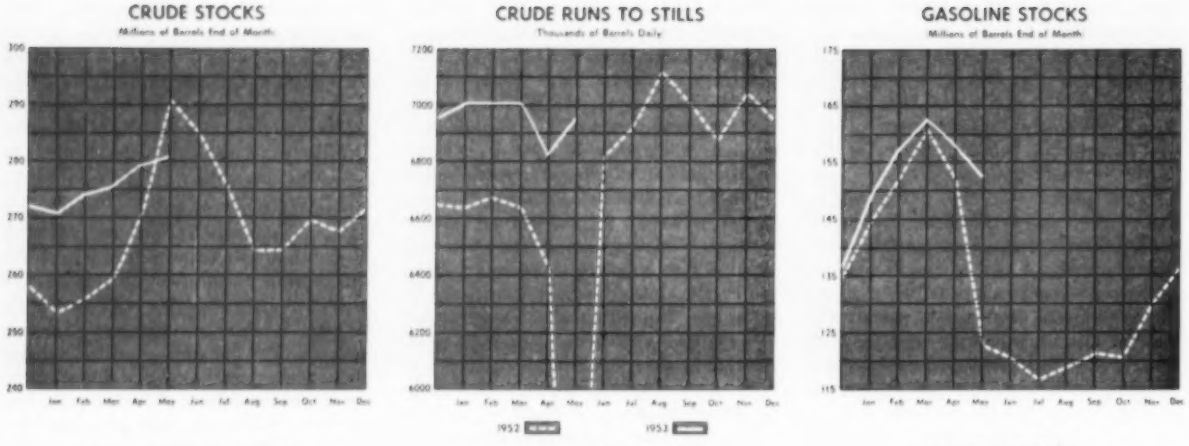
Such charts as these for the elimination of trial-and-error procedures may be constructed either from original experimental data or from the original curves based on these data. Murphy[10] has shown an example of how such data may be recalculated. The possibilities of this feature of dimensional analysis are virtually unlimited, as an inspection of Table 1, presenting some of the more common dimensionless groups, will show. A more complete list of dimensionless groups and their fields of application has been given by Murphy.[10]

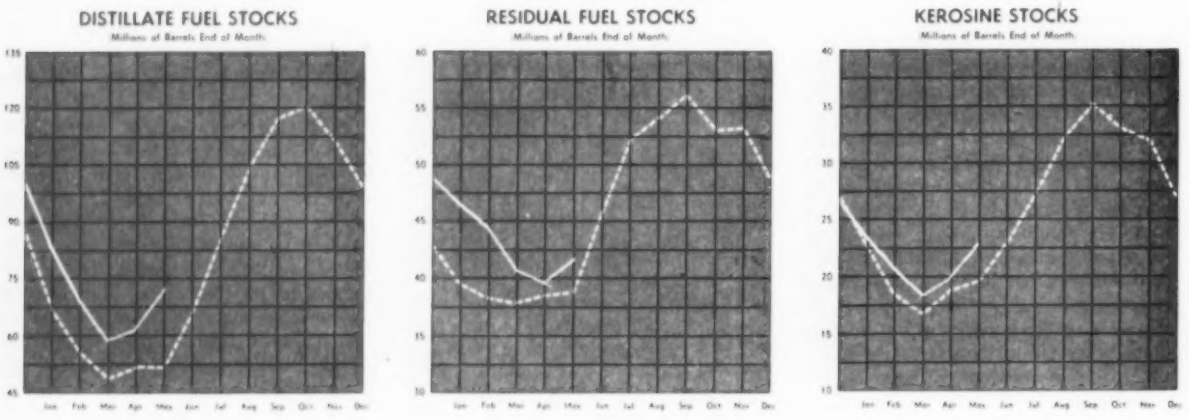
Engineering Applications

To attempt to list all of the engineering applications of dimensional analysis would be impossible. The technique has found use in a tremendously wide scope of experimental endeavors. Wilhelm and Kwauk[19] used four dimensionless groups to correlate pressure drop, fraction voids, and velocity in the problem of fluidization of solid particles. Leva[8] has employed dimensionless groups to correlate pressure drop through packed tubes. Brownell and Katz[3] used modified Reynolds numbers and friction factors to correlate the variables in the flow of fluids through porous media. The problem of the kinetics of simultaneous absorption and chemical reaction of carbon dioxide in alkaline solutions was treated by van Krevelen and Hoftijzer,[18] using the principle of dimensional analysis and the known relations for absorption in packed towers. The ever-increasing use of dimensional analysis serves to confirm its position as one of the most important and useful tools the modern engineer possesses.

End of Part IV and Series.

* For the meaning of the symbols, see Example 2 in Part III of this series, which appeared in June, 1953, *Petroleum Refiner*.




DISTILLATE FUEL STOCKS
Millions of Barrels End of Month
RESIDUAL FUEL STOCKS
Millions of Barrels End of Month
KEROSINE STOCKS
Millions of Barrels End of Month

Taking Stock

Cecil W. Smith
Economics Editor

(DATA IN THOUSANDS OF BARRELS)

MONTH	CRUDE OIL			GASOLINE		KEROSINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Crude Oil	Total Oils
1952:													
January	6,217	6,640	254,007	3,094	144,339	421	22,679	1,456	66,969	1,338	39,523	488	951
February	6,367	6,673	255,900	3,109	151,912	370	18,530	1,528	55,369	1,322	38,295	491	940
March	6,388	6,640	259,126	3,069	160,689	386	16,817	1,400	48,750	1,274	37,971	510	947
April	6,429	6,435	270,679	2,995	151,890	366	18,955	1,312	51,634	1,253	38,561	539	922
May	5,107	4,905	290,813	2,295	123,656	229	19,614	982	51,648	979	38,821	545	951
June	6,197	6,825	285,964	3,169	120,166	317	23,061	1,455	65,911	1,228	45,688	581	901
July	6,093	6,927	275,951	3,295	116,566	358	27,387	1,475	85,775	1,237	52,245	597	892
August	6,219	7,118	264,368	3,377	118,592	375	32,401	1,514	104,257	1,252	54,061	632	879
September	6,518	7,017	264,723	3,428	120,991	350	35,021	1,502	117,252	1,230	56,200	615	902
October	6,518	6,883	269,776	3,301	120,062	352	33,289	1,458	120,721	1,203	53,052	643	1,038
November	6,487	7,049	267,852	3,416	129,509	393	32,199	1,510	116,096	1,299	53,069	624	984
December	6,634	6,952	271,928	3,361	136,028	421	26,842	1,509	99,582	1,302	48,706	603	1,165
1953:													
January	6,555	7,042	272,250	3,384	150,518	433	23,292	1,528	80,655	1,307	45,910	616	1,135
February	6,562	6,969	273,589	3,379	157,873	404	20,468	1,505	67,167	1,275	44,178	586	1,066
March	6,531	7,002	275,665	3,319	162,731	359	18,697	1,489	59,802	1,256	41,600	655	1,112
April	6,284	6,804	279,187	3,262	157,711	380	19,867	1,401	61,037	1,241	39,092	637	996
May	6,349	6,952	280,285	3,321	152,457	351	23,628	1,383	71,695	1,228	41,572	693	1,054
May, 1953—Change:													
In Month	+65	+148	+1,098	+59	—5,254	—29	+3,753	—18	+10,658	—13	+2,570	+56	+58
In Year	+1,242	+2,047	10,528	+1,026	+28,801	+122	+4,014	+401	+20,047	+249	+2,751	+148	+103
Week Ended:													
6-20-53	6,470	7,083	278,543	3,363	149,535	339	26,930	1,443	82,701	1,243	43,937	700	936
6-21-52	6,155	6,805	287,645	3,180	121,613	311	21,865	1,484	60,905	1,228	42,822	578	854

Source: Data for last two months from API; prior monthly data from Bureau of Mines.

Bearing Failures—

Diagnosis and Prevention

Here is a concise analysis of why bearings fail and the proven methods for curing these ills.

H. W. Luetkemeyer,
Clevite-Brush Development Company, Cleveland

IN A BROAD sense, bearing failures can be identified as one of or a combination of the following:

- Fatigue
- Seizure and wiping
- Corrosion
- Erosion
- Wear, abrasion and scoring

A person acquainted with bearing failures can usually and rather accurately place a failed bearing in one or more of these catagories merely by visual examination. The reason for the failure, however, is not always so obvious. It is often necessary to submit the bearings to a laboratory for a metallurgical, chemical, and dimensional analysis. If further diagnosis is necessary, much can be learned from an investigation of the apparatus from which the bearing was taken. Unfortunately, there are times when the cause of a bearing failure remains a mystery, simply because certain operating details are lacking or the unit from which the bearing was taken cannot be reached or identified.

Most bearings outlive the mechanism in which they are installed. Others, although still in good running condition, are replaced during periodic overhauls. A third group, which represents a small minority, is replaced because of failure. It is these bearings that will now be considered.

Original presentation was at a Lubrication Committee meeting of the American Petroleum Institute, Detroit, February, 1953.

Fatigue Failures

In the past fatigue has been the most common type of bearing failure in applications with cyclical loading. It consists of cracking, raising, pounding out, or flaking out of the lining and is most apt to be found in the white metal alloys. Important factors that determine fatigue life are the strength of the alloy, the unit load, and the operating temperature.

Quite frequently, engine power ratings are increased without fundamental design changes in the bearing. The result is premature and unexpected failure due to loading the bearings beyond the point for which they were originally designed. Babbitts, although highly desirable from an embedability and anti-seizure point of view, represent the weakest family of metals in fatigue strength. However, their life is appreciably lengthened when their thickness as a lining is reduced below 0.010 inch. Here the fatigue strength of lead and tin base babbitt begins to improve at an ever-increasing rate so that at 0.002 inch an approximate 400 percent increase in life is realized. A lining thickness less than 0.002 inch on a steel back is not practical because of poor dirt embedability. Therefore, if micro babbitt (0.002/0.005-inch lining) continues to fatigue in a given application, a higher strength alloy is required. The following materials are listed in the order of increasing fatigue strength:

(1) Tin base babbitt
(2) Lead base babbitt
(3) Cadmium base babbitt
(4) Micro tin or lead base babbitt
(5) Copper-lead (up to 45% lead)
(6) Leaded bronze and aluminum base alloys
(7) Trimetal (0.001 in. white metal overlay on leaded bronze, aluminum alloy or silver)

Several bearing alloys, notably those in the copper-lead group, have a fatigue life that varies considerably with changes in metallographic structure. It has been proven from laboratory tests, for example, that the fatigue life of a cast copper-lead bearing having a uniform dendritic structure can be ten times greater than the same alloy cast and quenched with poor lead distribution, planes of lead near and parallel to the bond line, or continuous lead lines from the surface to the bond. In such cases the lead forms planes of weakness which encourage rapid propagation of fatigue cracks from the surface, down almost to the steel, and then parallel and close to the bond line. It is quite important, therefore, that every fatigued bearing be sectioned to ascertain whether its structure is proper.

Fatigue failure sometimes results from a poor bond between the lining material and the steel. Failure from this cause is characterized by a clean break of the alloy away from the steel. Whether or not this separation exists can usually be determined by a metallographic analysis of the bearing cross-section.

Since the selection of a bearing alloy is based primarily on the anticipated load, it is of prime importance that the load be calculated as accurately as possible. Unit bearing load calculations are based on the assumption that the total load will be uniformly distributed over the projected bearing area. Actually, however, this is not always the case. If misalignment exists between the shaft and bearing bore or if the bearing surface contains high spots, excessive localized loads will result. It is usually possible to recognize and determine the cause of such load concentration and fatigue. Off conditions that set up fatigue failures in characteristic locations are:

- Rod bend, such that the bore of the large end is not parallel with the bore of the small end
- Crankcase misalignment
- Shaft misalignment
- Cap shift

- "Hour glass" or "barrel" grind on the shaft
- A cammed condition worn on the shaft by a bearing with a partial annular groove
- A foreign particle between the back of the bearing and the housing
- Embedment of a large foreign particle in the running surface
- Fluted grind chatter on the housing bore
- A rippled, uneven finish on the bearing bore

From the wear and fatigue patterns of the above, a faulty engine condition can ordinarily be corrected and the bearing performance improved.

Along with load, operating temperature plays a very important part in determining bearing life. For example, the life of a tin base babbitt bearing is approximately doubled by reducing the bearing back temperature from 280 to 250 F. Since bearing cooling is accomplished mainly through oil flow, attention is constantly directed toward maintaining the flow at a practical maximum. Analysis of fatigue failures should always include an investigation of operating temperatures, particularly if the running surface shows evidence of heat such as lead sweat, melting of the babbitt, or dark discoloration. Abnormally high temperatures may be the result of scoring by foreign particles, excessive friction and inadequate cooling elsewhere in the engine, or a restriction of the oil flow, as through inadequate clearance.

Wiping and Seizure

With heavy-duty bearing materials such as copper-lead, leaded bronze, silver, and aluminum base alloys replacing micro babbitts, fatigue is being rivaled by surface wiping and seizure as the most common type of bearing failure. In general, strength is gained only at the sacrifice of softness and surface conformability. Besides being stronger, heavy-duty bearing materials are harder, less embedable, possess a higher modulus of elasticity and have a higher melting point than the babbitts. For these reasons the stronger materials usually require a thin overlay of a soft, conformable, low-melting material to accommodate any off-conditions that may otherwise lead to a surface failure. This overlay, which may be a tin or lead base babbitt about 0.001-inch thick, has greatly reduced but not entirely eliminated the wiping type of failure.

Surface wiping and seizure result from off-conditions that bring about a localized breakdown of the oil film. The inability of harder alloys to "heal over" once they encounter metal-to-metal contact accounts for seizures under conditions where a babbitt bearing would survive.

Off-conditions most likely to initiate film breakdown are:

- Hard foreign material carried by the lubricant
- Misalignment between the shaft and bearing
- Roughness of the shaft
- Low clearance
- Failure or restriction of the oil supply

The major cause of surface failures in heavy-duty bearings is dirt. Much of the foreign matter found in lubricating systems is of a size larger than the combined thicknesses of the oil film and soft bearing overlay and in many instances is even thicker than the diametral clearance. When such a particle is discharged into the center of the bearing and is not embedded because of the hardness of the lining, one or a combination of the following must result:

(1) Scoring of the bearing surface
(2) Scoring of the shaft
(3) Breaking up of the particle into pieces small enough to be flushed through the clearance area

Regardless of the cause, instantaneous surface heating occurs. Since the top temperature of this heating is the melting point of the lining, much higher temperatures are possible with copper, silver, and aluminum base materials than with tin or lead base babbitt.

To illustrate the tremendous amount of heat that may be absorbed by a single bearing during a seizure, consider a shaft operating at 1875 rpm and developing 90 hp. The kinetic energy of the moving parts and the energy developed by the engine horsepower during the period of seizure are dissipated into a single bearing. This energy amounts to a Btu value many times the potential energy of an acetylene torch operated over the same period of time. For an instant, therefore, a steep temperature gradient exists between the i.d. and the o.d. of the bearing.

At the moment the temperature gradient is established, a corresponding expansion gradient is formed such that the i.d. of the bearing attempts to expand the greatest amount and the housing bore the least. Because of the press fit of the expanding bearing in the cooler less-expanding housing bore, the bearing upsets, particularly in a circumferential path around the center where the scoring, distress and heat generation are at a maximum. Clearance is further reduced by a similar gradient imposed simultaneously on the shaft by abrasion and particle friction. The reduction in clearance from bearing upset and shaft expansion increases the amount of metal-to-metal contact, which in turn generates additional surface heat. The cycle continues either until the bearing lining seizes and stalls the shaft or until enough lining is wiped or melted out to accommodate the upset. After the bearing has cooled, the following three permanent dimensional changes may be noted as evidence of the high thermal distress to which the bearing has been subjected:

(1) A pronounced loss of crush (up to 0.010 inch)
(2) A pronounced loss of spread (up to 0.10 inch in a 2-inch diameter bearing)
(3) An arching of the steel back (up to 0.003 inch)

These changes take place regardless of which of the aforementioned off-conditions initiated the oil film breakdown.

Unless welded to the shaft, the bearing will usually continue to operate in spite of these dimensional changes. In such cases, oil will penetrate to the hollow in the back of the bearing and oxidize to form a tell-tale band of black deposit circumferentially around the center of the back. Continued operation results in repeated flexing of the hollowed back as the load revolves around the bearing. If allowed to run long enough, the flexing may produce an axial fatigue crack through the steel that will eventually separate the bearing in two.

Another occasional by-product of the surface wiping type of failure is the rupturing of the bond between the lining and the steel back. Subsequent breakout of the lining has the appearance of a fatigue failure but is actually the result of bond failure through heat subjugation.

Too often a seized or wiped bearing is mutilated to the extent that all evidence of the cause of the original film breakdown has been destroyed. The analysis must then be directed toward the installation where the following items are investigated:

- Engine cleanliness
- Main bearing bore, rod bore and shaft alignment

- Bore distortion study
- Engine lubrication study
- Clearances
- Shaft surface finish

Experience has shown that engine cleanliness is the most important factor in combating surface failures. This is particularly true when heavy-duty bearings are used in the replacement field following an overhaul or in areas where dirt and dust particles from the air are apt to contaminate the lubricating system as in mining, earthmoving, or desert operations.

The lubrication study is made from lubrication formulae and is conducted to guarantee that sufficient oil is being supplied to the bearing. The calculation takes into account bearing clearance, the viscosity, pressure, and temperature of the oil, hole and groove design, bearing load, and shaft speed. Although greater flow and cooling is expected with lower viscosity oils, the film thickness is reduced. This may increase the amount of surface scoring and be instrumental in developing higher surface temperatures and surface wiping.

Corrosion

Corrosion, which is confined largely to copper-lead and cadmium alloy bearings, is visually differentiated from fatigue by appearing generally over the entire bearing surface, even in the unloaded zones. At times fatigue and corrosion occur together in the same bearing. When lead is removed from between the copper dendrites, the structure is weakened and will collapse under load and break out in a typical fatigue fashion.

A laboratory analysis is usually necessary to definitely identify corrosion. For example, it is sometimes difficult to distinguish between loss of lead through corrosion and loss through high temperature lead sweat. In such cases it is necessary to prepare a metallographic specimen of the failed portion of the bearing and study the copper-lead structure. If there is a general deleading of the bearing surface, either corrosion or lead sweat has occurred. If the sides of the copper dendrites in this area are completely devoid of lead, the bearing has corroded. Lead sweat, which results from a melting out of the surface lead because of an oil film failure, always leaves a thin film of lead adhering to the copper dendrites.

A second and less accurate form of metallographic corrosion analysis is the fracture test, which consists of sharply reverse bending a copper-lead bearing and observing the color of the exposed lining fracture. A gray fracture denotes adequate lead and a red fracture is suggestive of lead corrosion.

A third check for corrosion can be obtained from an analysis of the oil. This includes such items as appearance, neutralization number, copper, lead, iron, sulfur and ash content, and the identification of filterable solids. Any metal attacked by the lubricant will have gone into solution and can be chemically identified by precipitating out as part of a soap. Too often, however, a sample of the oil from a field failure is not saved and a valuable analysis tool is lost.

Corrosion in copper-lead increases rapidly with the coarseness of the structure, the lead content, oil oxidation, detergency and acidity, and high operating temperatures. There have also been instances where corrosion resulted from operation at engine temperatures below 210 F. It is generally recognized that copper-lead corrosion is minimized when the oxidation or corrosion inhibiters plate out or form a protective film on the active metal surfaces. However, since this reaction is somewhat controlled by engine operating temperatures, the films will not form if the temperature is too low. When corrosion of copper-lead occurs under conditions which do not indicate high temperatures of oil deterioration, the presence of moisture, blow-by, and general operating conditions of the engine can either contribute to or be a direct cause of bearing corrosion.

A 0.001-inch thick protective lead base overlay, which, as previously pointed out, increases the fatigue strength and reduces the surface sensitivity of heavy-duty bearings, performs a third valuable function in improving the corrosion resistance of copper-lead or leaded bronze bearings. Unless this overlay is worn off or deeply scored, there is little chance of corrosion occurring in practically all present-day applications. There have been instances, however, where, after scoring had exposed the copper-lead, corrosion penetrated deeply into the intermediate layer and also progressed laterally beneath the overlay.

Lead base babbitts corrode at a much slower rate than the free, uncombined lead in a copper-lead mixture. If conditions are excessively corrosive, however, a lead alloy will be attacked leaving a rough, pitted surface, which has a scalloped contour when viewed in cross-section under a microscope. Corrosion has never been a problem in tin or aluminum base alloys.

Fretting is a special type of corrosion that is typified by localized discoloration and minute surface pitting. It may be found on either the bearing or shaft member and is attributed to high vibratory loads between two mating surfaces having very slight relative motion. It is found in heavy-duty bushing applications involving heavy loads and only slight oscillatory motion, as in piston pins and steering knuckles. It also occurs on the backs of bearings that fit loosely in their housings. In this case it is reduced by increasing the press fit so that the motion between the back of the bearing and the housing bore is reduced to a minimum.

Erosion

Erosion is of two varieties. One type is recognized by the removal of material previously weakened through fatigue or corrosion. Breakout occurs in nearly straight lines which follow the direction of oil flow.

The second and less understood type of erosion is cavitation. It is usually found in high speed applications and seldom in the automotive or diesel fields. Rarely is it associated with other types of failure. Cavitation is a localized phenomenon, occurring under special conditions of load, shaft speed, groove design, and vibration. It is identified by a pitted surface and usually assumes a typical erosion pattern. It is not confined to bearing surfaces alone but is also experienced on other engine parts, including the steel running surfaces of high speed shafts. Correction of this condition, or at least a lessening of it, is sometimes possible by the application of flats to the journal, axial grooves in the bushing or bearing surface, changes in lubricant flow, changes in the lubricant entry location, or if in a gear bushing, altering tooth profile for smoother gear operation.

Wear, Abrasion and Scoring

In conclusion, the surface of a used bearing reflects the cleanliness of its engine. A large amount of foreign matter embedded in a soft babbitt lining, the scoring of a heavy-duty bearing, or an appreciable amount of shaft wear are indicative of excessive engine dirt. This represents the most serious cause of bearing failure today. In addition to wearing and abrading the bearing, foreign particles lead to high operating temperatures, lower fatigue life, interrupted oil film, wiping and seizure.

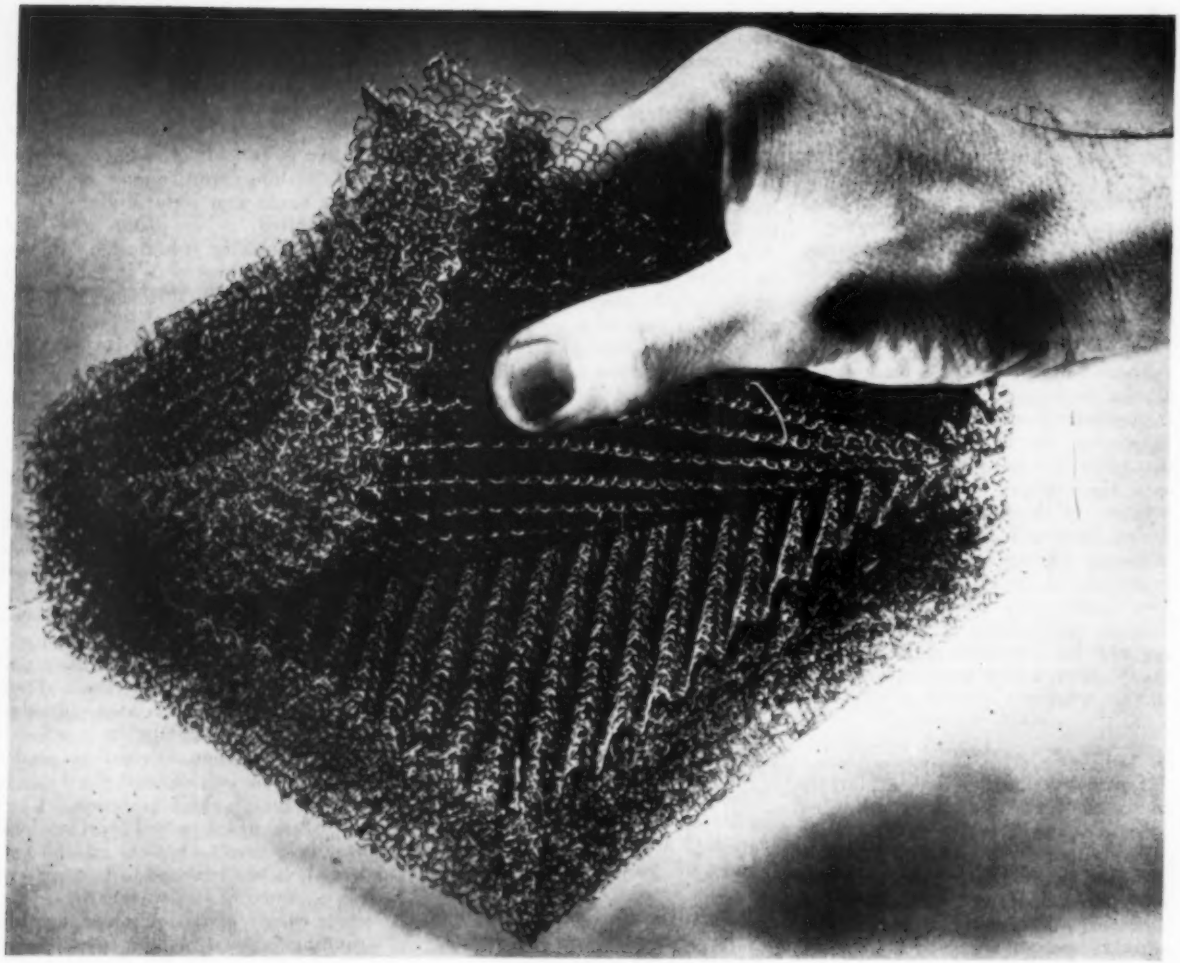


Figure 1. A section from a wire mesh entrainment eliminator is held open to show its construction.

Entrainment Eliminators Save Money

All refineries have the entrainment problem but all are not aware of this simple, economical solution to their troubles.

Sanford C. Reynolds, Metal Textile Corporation, Roselle, N. J.

IN ANY PROCESSING operations involving the handling of liquids and gases in intimate contact, ultimate separation of these two phases is never complete, and varying amounts of liquid are always found entrained in the effluent gases. Since this is the result of physical or mechanical and not chemical reactions between the gas and the liquid, it is logical that industry should look to mechanical means for its control. The word "control" is used advisedly, since the formation of this entrainment cannot be prevented by any means now known.

MAINTENANCE / OPERATION

Meaning of Liquid Entrainment

Whenever a gas is generated in or passes through a liquid, that gas will carry with it, on disengaging from the liquid surface, varying quantities of small liquid droplets which are caught —entrained—in the rising gas. A similar condition results when a gas is scrubbed or sprayed with a liquid.

This entrainment, or liquid carry-

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over as it is often called, is a true liquid in the form of dispersed droplets some of which may be as small as 1 to 2 microns in size. It must not be confused with a liquid "fog" which consists of particles so small in size that they will float on still air like smoke.

Liquid entrainment, therefore, can be found in practically any vessel in a modern refinery or processing plant, and may often occur in several places, or stages, within a single vessel. Typical of these vessels are: vacuum or atmospheric towers, stills, absorbers, scrubbers, compressors, fractionating towers, reactivators, evaporators and the like. In fact entrainment, and petroleum refining and processing are inseparably linked from the well head to the finished products.

Effects of Entrainment

In general, the effects of entrainment are evidenced in one of two ways. In some cases the liquid is carried off in the effluent and becomes a direct loss to the operation, or a contaminant to the atmosphere or surroundings. In other cases the liquid is carried on to a subsequent step in the refining process. Here it may contaminate that operation, reduce its effectiveness, cause undue corrosion or otherwise interfere with processes which are in themselves sufficiently delicate and involved.

In either case, liquid entrainment is an unavoidable concomitant to refining and processing operations, and is a condition that must be taken into account not only in plant operation, but in plant design as well.

Background

A search through several basic text books on refining and chemical engineering has revealed little information on entrainment—and less on the means by which it can be controlled. This might be interpreted to mean that entrainment has become accepted as an inevitable and unavoidable evil, just as our ancestors regarded the common cold. It would probably be more accurate to assume that the calculated efficiencies of the conventional means of removing entrainment have appeared to justify the cost of installing and operating them only in the most serious instances.

It is not the intent of this paper to discuss the advantage or shortcomings (if any) of such conventional methods as baffles, centrifuges, louvres, precipitators, knock-out drums and the like.

But when the removal of these minute liquid droplets was studied as a problem in filtration, the employment of those physical and mechanical principles which have long since demonstrated their effectiveness in removing minute solid particles from gas and air streams, has resulted in a simple, practical, highly efficient and economical solution to the problem. In fact, the "filtering out" of liquid droplets is far simpler in one respect: the filtrant, being liquid, can be made to drain itself from the filter by gravity.

> "The use of **knitted wire mesh separators** in the top of our lube towers has **cut lube losses** to one-fifteenth of what we previously experienced. We wouldn't operate a refinery without them. They more than pay for themselves in a very few weeks."

The Solution

The result of this approach to the entrainment problem is the knitted wire mesh entrainment separator. A glance at the photograph reproduced in Figure 1 will show its similarity to air and dust filtration media. How it works, how it should be used, what results can be expected and how its use can affect not only refinery operation but plant and vessel design will be discussed later. For the present let us consider what it is.

FIRST: It is a unit, foraminous in structure, made by assembling layers of knitted—not woven—wire mesh into a pad consisting of a multiplicity of unaligned, asymetrical openings.

SECOND: It removes the entrainment by impingement and accumulation in depth, as opposed to filtering by screens or sieves with minute and regular openings.

THIRD: Its structure contains sufficient wire surface area—approximately 125 square feet per cubic foot in the standard pad—to remove and collect practically 100 percent of the entrained droplets under proper velocities and pressures.

FOURTH: Its unusually high free volume—approximately 98 percent—causes minimum restriction to vapor flow and results in a pressure drop generally less than one inch of water at atmospheric pressures.

FIFTH: It can be knitted and constructed of practically any metals or alloys (and many plastics) that are available in wire form, thus reducing the problem of corrosion to a minimum.

SIXTH: There is no limit to the size in which they can be made. They are furnished in two types:

- Single piece wound units, generally 4, 6 or 8 inches thick and up to 30 or 36 inches in diameter.
- Large sectional units made from laminated strips, generally 4 inches thick and approximately 12¼ inches wide, for easy passage through a man-way. Sectional units are factory-cut to fit the size and shape of the vessel in which they are to be installed, including cut-outs, angles and flats.

SEVENTH: They require no special housings, containers or connections and are installed within the vessel or tower on supporting bars or gridwork of light-weight open construction similar to subway grating.

EIGHTH: They contain no moving parts to require attention or power, and there are no valves or gates to be opened and closed.

Operation

As the entrainment-laden gas passes through the knitted mesh unit, the liquid droplets impinge on the wires and are removed from the gas. Since the direction of flow is being continually changed as the gas swirls around to seek passage through the maze of wires, impingement of all the droplets is made easier and surer due to the inertia of the heavier liquid particles. As the impinged droplets build up on the wires, they coalesce and form large drops which flow down through the mesh and fall off into the rising vapor flow. The entrainment is literally wiped out and returned; the gas passes on, freed from the objectionable liquid.

You may think it questionable that a four-inch thick unit, with openings so large that you can see light through it, will stop and remove particles some of which are as small as 1 to 2 microns in size. You can see light through a privet or barberry hedge, too; but when you were watering the lawn, with the nozzle adjusted for a fine spray, and turned the hose on the hedge, you didn't get the outer sidewalk wet, did you? The reason and the results are similar, and have been proved by many an installation.

Correct Usage

Naturally a knitted wire mesh entrainment separator must be installed and used correctly for best results, but experience has shown that it will function under a far wider range of operating conditions than will other types of separators. Specific conditions may require special study, but the following four basic principles will give the answer to most entrainment situations.

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FIRST: For best results units should be installed horizontally, so that the liquid which has been removed from the vapor stream can drain down, and out of, the pad. With vertical installations, the liquid, after being removed by the wires, tends to work through to the free side of the pad as it flows down through the mesh. Units installed at an angle will give better results, but do not approach the efficiency of horizontal separators when angle is more than 35 degrees.

SECOND: Effective entrainment removal is secured at operating velocities which cover an unusually wide range, the upper and lower limits of which can best be defined as follows:

- On the low side, velocities must be high enough to force the droplets to impinge on the wires, but must not be so low that there is a tendency for some of the smaller particles to drift through the pad.
- On the high side, velocities must not be so great that the liquid, after being removed, cannot flow back against the vapor flow, and will be blown off the top and reentrained.

Just what these limits are depends upon the operating pressure, the specific gravity, viscosity and surface tension of the liquid, and the density of the carrier gas. Stokes Law has been found to be an excellent guide.

A better idea of the unusually wide range of velocities under which these units will function effectively is given by the fact that better than 99 percent entrainment removal will be found, with water and air, at velocities ranging from 2 to 12 feet per second—120 to 720 feet per minute—at atmospheric pressures. Under vacuums, the upper limits may be increased to 20 feet per second or more, while under pressures the upper range should be reduced, since the greater density of the gas will correspondingly obstruct the free fall of the coalesced drops.

In either case, the use of a wire mesh entrainment separator will assure practically complete entrainment removal over a far wider range of operating velocities. And this in turn means a wider range in volume input for any given vessel, and greater operating flexibility.

THIRD: While an entrainment separator of this type will remove liquid particles down to about two microns in size, greatest efficiencies result when a high percentage of droplets are in the range of five microns and up. In other words, when small ones are mixed with larger ones, a larger proportion of the smaller ones will be removed. It is neither necessary nor advisable to first pass the vapor through a preliminary separator which can only remove the larger particles. This would be like calling one or two strikes on a batter before he came to the plate.

FOURTH: Since wire mesh entrainment separators are designed to function at greatest efficiencies with liquids, the possible presence of solid matter in the entrainment should be considered. If the quantity of solid matter is small, it will generally be washed out by the returning liquid. When large quantities of solids are present, or when salts may be deposited on the wires, restriction may increase until the openings become plugged and the unit will cease to function. Except in the most serious cases, periodic backwashing will serve to remove the restriction.

Results

The direct result of using this type of entrainment separator, under the operating conditions previously outlined, will be the removal and return of more than 99 percent of the liquid entrainment. The ultimate results can only be determined by evaluating either the value of the waste material no longer lost, or the increased efficiency of subsequent operations which no longer must function under the handicap of the undesirable liquid which was produced in some preliminary step in the succession of operations from crude oil to finished products.

That these latter considerations enter into practically every step in refining processes is all that need be said.

Effects on Plant Operation and Design

The effects of removing objectionable entrainment on plant operation have already been mentioned earlier in this paper. While differences in processing and in the feed stock used in individual refineries have made operators understandably reluctant to lend their names to "performance reports," the significance of the following comments cannot be overlooked.

"The use of knitted wire mesh separators in the top of our lube towers has cut lube losses to one-fifteenth of what we previously experienced. We wouldn't operate a refinery without them. They more than pay for themselves in a very few weeks."

So much for direct losses. Now for only one comment on the increased efficiency of subsequent refining operations due to the removal of contaminating liquids.

"Without a wire mesh separator above the flash zone in our stills, we would have to degrade our catalyst and cut our on-grade production by 10 to 15 percent."

These comments of continuous users which, incidentally, are two of the largest refiners in the country, whose products are available at service stations from coast to coast, represent two extremes of what may be expected from these wire mesh separators by those who are responsible for plant operation.

From the viewpoint of plant designers, there is one outstanding feature that cannot be lightly dismissed—increased production from a given vessel. Since these vessels can then be operated at far higher velocities than are normally calculated, two very desirable results are in your hands.

FIRST: You can obtain higher thruput from an existing vessel because it can be operated at higher velocities without the damaging effects of otherwise inevitable entrainment.

SECOND: New vessels can be made smaller for a given thruput with consequent lower costs. For example: It would require a six-foot diameter knock-out drum to handle the entrainment in 2.5 Mmcf per day thruput at a velocity of 1 to 2 feet per second under atmospheric conditions. And at these low velocities, only a small portion of entrained droplets less than 100 microns in size will be removed.

But the same volume thruput can be handled in a 2-foot 6-inch or 3-foot drum, operating at 5 to 6 feet per second velocity with a knitted wire mesh entrainment separator. Not only will more entrainment be removed, but the cost of the pot will be materially less. This cost differential will be more important yet with pressure vessels.

Cost

While the price will depend on the size of the separator and the metal of which it is made, you can roughly calculate that $9 to $10 per square foot will cover the cost of 75 percent of the entrainment separators now in use made of 18-8 stainless steel. Carbon steel separators will cost about one quarter as much.

Results of using these separators have proved that "filtering out" liquids is not so different from filtering out solids when the simple basic principles are understood and applied. Entrainment need no longer be tolerated. It can be controlled simply, effectively, and economically, to the benefit of unnumbered processing operations.

MAINTENANCE / OPERATION

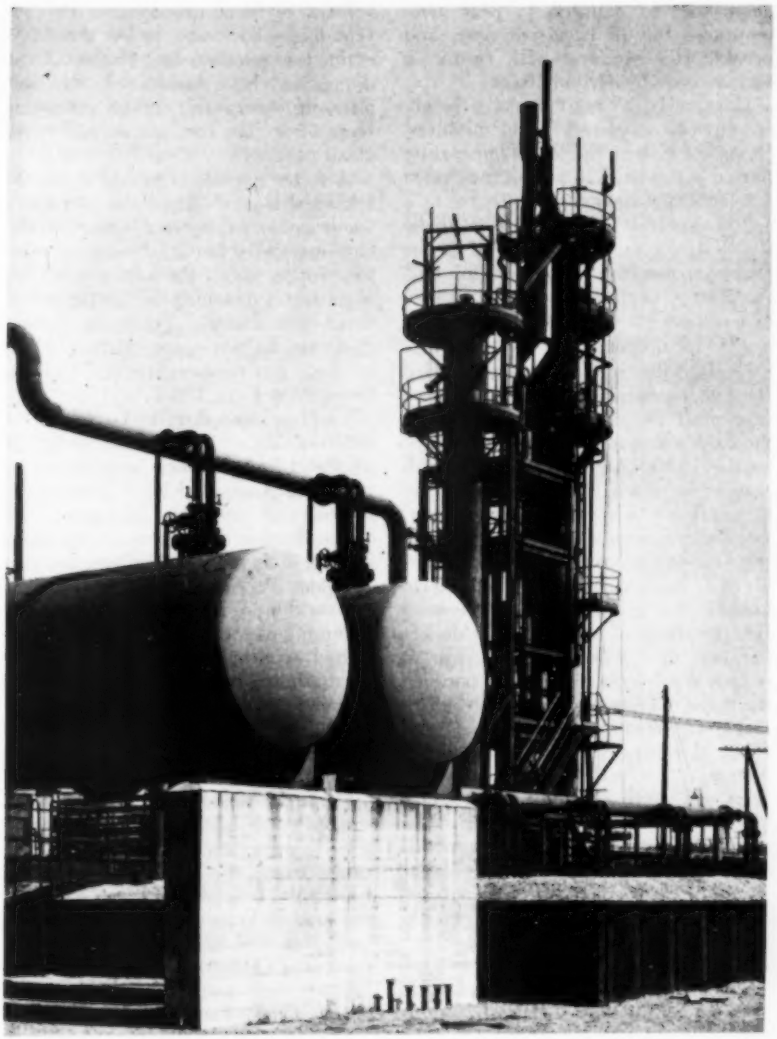

Figure 1. Hypersorber towers can serve in the purification of acetylene. (Photo courtesy The Dow Chemical Co.)

Uses of Oxygen in the Petrochemical Industry

Part II. Commercially used reactions

- Acetylene
- Ethylene
- Ammonia

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ACETYLENE is certainly one of the most versatile single starting materials in organic synthesis. The range of its products defies detailed description in this place. This aspect has, in recent years, been the subject of a number of good books and reviews.

Here it will suffice to recall some of the products which are today produced in very large quantities from acetylene. Chronologically, acetaldehyde ranks in first place on this list. Principal recent expansion has been in the fields of synthetic fibers and plastics. It has been here that petrochemical processes have been called upon to serve for acetylene production.

Vinyl chloride is today still the most important acetylene-derived monomer. (In this connection, it must be noted that an appreciable portion of the vinyl chloride output in the United States is produced by the competitive dehydrohalogenation of ethylene dichloride.)

Acrylonitrile, used in the production of Buna-N rubbers and of the synthetic fibers Orlon, Acrilan, Dynel, etc. has experienced a particularly rapid growth since the turn of the half-century. In its synthesis, the petrochemical industries serve as source for both acetylene and hydrogen cyanide, the raw materials for acrylonitrile production.

Other acetylene-derived monomers are of more limited significance. They include vinyl acetate and vinyl acetylenes. In addition, acetylene serves as raw material in the synthesis of significant amounts of chlorinated hydrocarbons and of neoprene-type rubber.

As yet, petroleum hydrocarbons are not the major starting point in the production of acetylene. At this writing, the classical route via calcium carbide is still the basis for most of the country's acetylene generating capacity. Acetylene production from methane is today practiced at two (or possibly three) large-scale plants, with another one in the construction stage.

The general trend of engineering thinking during recent years has tended to favor petroleum gases as a source of acetylene for large-scale installations at sites where gaseous hydrocarbons are inexpensive. The next years will most certainly see considerable expansion in this field.

Production of acetylene from methane takes place in accordance with Equation (5).

$$2\ CH_4 \rightarrow C_2H_2 + 3\ H_2 \quad \ldots\ldots\ldots\ldots (5)$$

The reaction is highly endothermic (164,000 Btu per pound-mole). In the partial combustion process, a portion of the feed hydrocarbon is consumed

by oxygen to yield carbon monoxide, hydrogen, and—within the limits of the water gas equilibrium—carbon dioxide and water.

We cannot therefore speak, in this connection, of a theoretical Oxygen/methane ratio without reference to the thermal characteristics of the system (preheat, heat losses, peak temperature).

Typical oxygen/methane feed ratio is 0.55-0.60, i.e., in the same range employed for the production of synthesis gas. Employing a preheat temperature of 750-930 F. for both gases, an over-all reaction is obtained which corresponds approximately to Equation (6).

$$51\ CH_4 + 30.25\ O_2 \rightarrow 8\ C_2H_2 + 3.5\ CO_2 + 25.5\ CO + 54\ H_2 + 28\ H_2O + 7\ CH_4 \quad \ldots\ldots\ldots (6)$$

The formation of acetylene is observed in any oxygen-methane flame. However, at flame temperatures, it is an unstable compound, intermediate in the formation of carbon and its stable oxides. To isolate acetylene, means must be provided to attain uniformity of the feed mixture almost instantaneously and to shock-cool the burner products before secondary (acetylene-destroying) reactions can become excessive.

Optimum reaction time depends on operating temperature. At 2730 F. (which is typical for the partial combustion process), it is of the order of .01 seconds. A water quench serves to freeze the product composition.

Ideally, all products should have a uniform residence time. In the ideal burner, therefore, we would have a flame front at right angles to the gas stream. Actually, however, such a flame is unstable and cannot be achieved.

To approximate this ideal flame, the burner is subdivided into a number of sections. The resulting over-all reaction space is short but has a wide cross-sectional area.

In a unit of this design, the reaction mix reaches peak temperature in a number of small parallel flames. The hot gases issuing from the flame envelope are still subject to high-temperature reactions until they reach the quenching point about eight inches from the burner exit.

Based on this consideration, Ullmann[7] has listed the following requirements for a multi-passage burner:

(1) Gas composition must be perfectly uniform in all of the passages since flame velocity is strongly influenced by this variable. If, for instance, a local excess of oxygen should occur, the corresponding flame would be reduced in length. (In extreme cases, this may actually result in flash-back of the flame). As a result, the product gases will be exposed to peak temperatures for an excessive time, and breakdown reactions will result in serious acetylene yield loss.

Conversely, a long flame will be observed with oxygen-deficient mixtures. In such a system, the high-temperature period is too brief to permit maximum conversion of methane.

(2) No less important is uniformity of linear gas velocity in all of the burner passages. The effect of this variable on contact time within a space of constant length is evident.

(3) In order to achieve the uniformity of flow and composition called for by considerations 1 and 2, great care must be given to the design of the feeder line to the multiple-passage burner block. Another design consideration is raised by the impossibility of obtaining a perfectly horizontal flame sheet, even if a large number of subdivisions is employed. The center of each flame will always exceed in length the circumferential elements (cf. the flame of a Bunsen or Meeker burner). It is, however, possible to reduce the length differential between the flame elements by the use of baffles inside the burner passages (with the effect of raising the turbulence of the system).

(4) In spite of these precautions, high-temperature residence time at the circumference of any one passage will be greater than in the center. In order to minimize acetylene breakdown, design must be based on the longest expected contact time obtained for any significant element of flame. Very high gas velocities must be employed. This is made feasible by the use of multi-passage burners since a flame fed by high-velocity gases is more stable on a burner of small diameter. The maximum permissible gas velocity is set by considerations of flame stability. Ullman[7] illustrates the high velocities involved by reference to an existing commercial acetylene producer chamber in which the throughput velocity is 150,000 scf per hour per cubic foot reaction volume.

Figure 2 shows a partial combustion burner based on these design considerations. The unit was developed at Ludwigshafen, Germany, for use with the Sachsse process which has now also become commercially important in the United States.

The upper passages leading to the burner block are designed for the attainment of highly uniform gas composition and flow. The burner passages themselves have a diameter of about $^3/_8$ inch and a length slightly exceeding 20 inches. (Ceramic construction materials are used throughout.)

The gas must travel faster than the velocity of flame propagation (to prevent flash-back) and below the flame extinction velocity. In passages of the dimensions here considered, this permits an operating range extending from 60 to 120 feet per second (with clean gas).

A water quench is provided. In the Ludwigshafen design, the primary water spray is injected from 40 circumferentially located nozzles, some four inches below the burner exit. The main water quench plane is located at twice this distance from the burner elements. In the course of this shock-cooling, gas temperature is lowered from 2900 F. to 160 F.

Carbon, formed in the course of the reaction, accumulates at the underside of the burner block and must be periodically scraped off to prevent obstruction of individual passages.

The burner is the core of the process and is its most difficult engineering problem. Process flow is quite simple (up to the point of purification). The incoming oxygen and methane are preheated separately to 750 F. in order to minimize oxygen consumption. A higher degree of preheating would increase the danger of backflashing in the burner.

The hydrocarbon feed should be of high purity since the presence of hydrogen or carbon monoxide brings on a real danger of backflashing. For the same reason, the presence of dusts, especially iron dust, in the feed gas must be rigorously avoided.

The oxygen/methane ratio must be carefully controlled—the optimum is between 0.55 and 0.60. Too litle oxygen will decrease the extent of the reaction due to insufficient thermal effect. Too much oxygen results in reduced acetylene yield due to excessive burning of hydrocarbons (as well as due to excessive temperature at a predetermined contact time).

The acetylene yield is approximately 31 percent of theory. A typical outlet gas contains:

C_2H_2	8-9	percent
CO_2	3-4	
CH_4	6-7	
CO	24-26	
H_2	56	

About 1.25 pounds of carbon is formed per mcf of feed gas. Some of this accumulates at the burner, as has been outlined above. However, the bulk is carried out of the burner as a dust and must be removed by filtration or electrostatic precipitation (or both).

Methods for purification of acetylene include the use of absorption in suitable organic media (dimethyl formanide, acetonyl acetone, etc.) or the high-pressure absorption in water in

accordance with a system described by the author in an earlier paper.[9] The latter method has been used in Germany and is being employed in at least one large-scale American installation.

Hypersorption (i.e. continuous countercurrent adsorption) appears promising for the recovery of medium-purity acetylene from partial combustion gases. See Figure 1. Berg et al.[10] have reported performance for a hypersorption unit as shown in Table B.

TABLE B

	Feed	Mol Percent	
		Top Product	Bottom Product
Hydrogen	48.4	54.4	...
Carbon Monoxide	32.3	36.2	...
Methane	6.0	6.7	0.1
Carbon Dioxide	4.0	2.5	16.2
Acetylene	9.2	0.1	82.8
C_2+	0.1	...	0.9

The off-gas produced in the partial combustion process is a mixture of hydrogen and carbon monoxide, containing also some 7 percent methane and up to 3 percent carbon dioxide.

Utilization of this by-product synthesis gas is an important factor in rendering this method of acetylene production economically attractive. Methods for the removal of carbon dioxide are in common usage (ethanolamines, other caustic scrubbing processes). More difficult is the removal of methane from the system. Partial combustion may be used for this operation as well. Oxygen consumption is some 5 percent of the lean gas treated.

The economics of acetylene production by various processes has been studied by Sherwood.[9] More recently, this subject has been investigated by Happel and Maisel,[11] who have arrived at the same overall conclusions. Using partial combustion and hypersorption, Happel reports an acetylene cost of 9.54 cents per pound for 15 cents per thousand standard cubic feet methane. This figure assumes by-product synthesis gas credit at its fuel value of 15 cents per million Btu or roughly 5.6 cents per thousand standard cubic feet.

In an integrated plant, which has chemical use for synthesis gas, by-product credit may fairly be assigned at 13 cents per thousand cubic feet (allowing for after-purification). In this case, acetylene costs are reduced by roughly one cent below the figure stated above.

It should be pointed out that partial oxidation is also technically feasible for the production of acetylene from ethane and even higher hydrocarbons. Present-day economics militate against such an approach, however, in spite of the somewhat better yield which can be obtained.

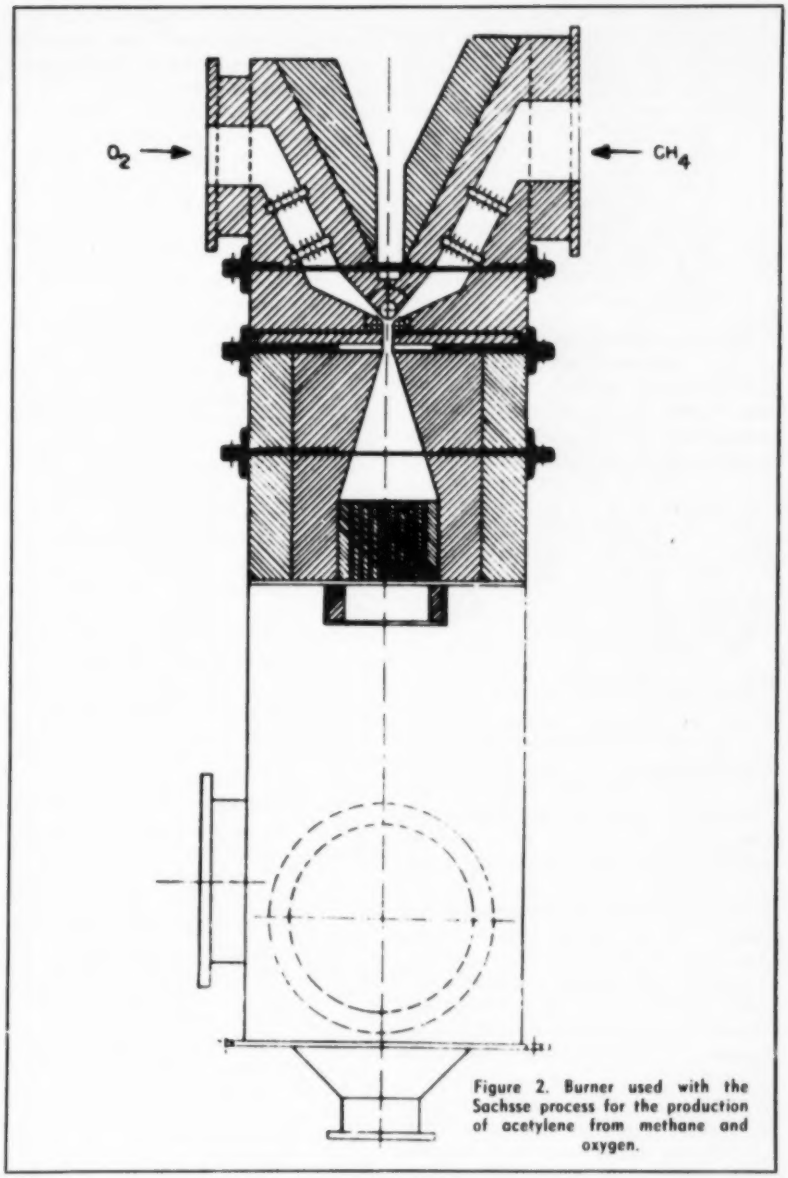

Figure 2. Burner used with the Sachsse process for the production of acetylene from methane and oxygen.

Ethylene by Partial Combustion

This process is reported here for the sake of completeness only. It has been used on a commercial scale at one German plant (Leuna), but its fuel-saving features have never been sufficiently significant to attract commercial interest in the United States.

A somewhat analogous process for the production of ethylene by partial combustion with air (rather than oxygen) has been developed by Universal Oil Products Co.[12] This method appears to hold long-range promise but is not within the scope of this discussion.

Ethane serves as raw material in the production of ethylene by partial combustion. As in other (i.e., purely thermal) methods of ethylene production, equation[7] applies:

$$C_2H_6 \rightarrow C_2H_4 + H_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

The reaction is reversible. However, because of secondary reactions, which result in the degradation of ethylene, only a pseudo-equilibrium can be attained.

The partial combustion process offers two advantages:

(a) Simplicity of reactor design. Reaction[7] is endothermic. Standard pyrolitic processes supply the required heat of reaction by indirect heat exchange through pipe coils made of high-temperature alloy. In partial combustion, enough hy-

drogen and hydrocarbon are burned to CO, H_2O and CO_2 to render the operation autothermic. Heat exchange surfaces are therefore not required in the reactor and ceramic construction material can be employed.

(b) Since product hydrogen is burned preferentially in a properly executed partial oxidation process, the ethane-to-ethylene decomposition equilibrium is shifted to the dehydrogenation side and higher conversion per pass can be achieved than is possible in purely thermal processes.

From considerations of flame mechanism, it can be shown that the presence of a large surface in the combustion system tends to minimize the combustion of hydrocarbon.[13] The oxidation of hydrogen, on the other hand, is not subject to any such surface effect. By carrying out the partial combustion in the presence of large surfaces, it is therefore possible to oxidize by-product hydrogen preferentially while keeping the destruction of ethane and ethylene at a minimum.

The Leuna process therefore employed a reactor filled with 1¼-inch ceramic spheres. Gas flow is upward. To achieve thorough mixing of the reactants, ethane enters through an annular passage at the reactor base. Oxygen is injected into this stream in high-velocity jets issuing from tangentially placed nozzles. Mixing is complete within twelve inches above the merging plane of the reactants. The feed gases then enter the ceramic-ring-packed reactor proper via a baffled distributor zone.

Ethane and oxygen are fed in 3:1 ratio. The reactants are preheated separately to 1100-1200 F. and 750 F. respectively, before they enter the burner.

Maximum temperature in the cracker is 1620 F. A partial vacuum of 3-400 mm Hg is maintained. The cracked gases are cooled, first by indirect heat exchange and finally by direct contact with water.

Ethylene yield is 60-65 percent of theory. A typical cracked gas contains 31 percent ethylene, 17 percent ethane, 38 percent CO plus hydrogen, the remainder being mainly methane and carbon dioxide. Oxygen content of the raw gas is reported at 0.6 percent.

Oxygen in the Partial Oxidation of Ammonia

This is a "second-generation" petrochemical operation. Ammonia itself may well be looked upon as a major petrochemical product today. Indeed, well over fifty percent of the national output of this basic chemical is derived from synthesis gas produced from methane.

The standard process for the production of nitric acid from ammonia involves air oxidation in the presence of platinum-rhodium catalysts. The reaction product (NO_2) is absorbed in weak nitric acid or water to yield a product of 50 percent concentration. The acid may be fortified to 98 percent by stripping in the presence of sulfuric acid. In the course of this operation, the sulfuric acid is diluted and must be re-concentrated in an auxiliary plant.

Certain operating advantages, including the complete elimination of the sulfuric acid cycle, can be gained by the use of oxygen for the production of strong nitric acid. Processes based on this principle have already found significant commercial acceptance in Europe. Announcement has recently been made that such a plant is also to be erected in the United States.

Of importance are the Bamag-Meguin processes for the production of 98 percent acid. Two versions are available using oxygen instead of air as combustion agent.[14] In the first of these, the entire oxidation is carried out by means of oxygen. Some 5.5 pounds oxygen are consumed for the production of one pound concentrated nitric acid. The process is of interest where by-product oxygen is available cheaply (e.g., at calcium cyanamide plants) or in areas of low power costs.

Of wider interest is the two-stage production of nitric acid, in which air is used for the primary combustion stage. Oxygen is substituted as oxidant in the absorption stage. In this version, oxygen consumption is about 0.9 pounds per pound HNO_3.

The advantage of the process, which makes possible the elimination of fortification by means of sulfuric acid, is related to the high oxygen concentration in the absorber column. Nitric oxide is absorbed in accordance with the reactions:

$$3\,NO_2 + H_2O \rightarrow 2\,HNO_3 + NO \quad \ldots(8a)$$

$$NO + \tfrac{1}{2}O_2 \rightarrow NO_2 \quad \ldots(8b)$$

In this process, Equation (8b) is rate-controlling. Since this is a gas-phase reaction, an increase in the partial pressure of reactants will raise the reaction velocity. The elimination of nitrogen has the effect of such an increase. Sze[15] has shown that the use of oxygen may actually boost the reaction rate by as much as 40 times.

This improvement in reaction velocity permits a substantial reduction in the space provided in the absorber for the gas-phase oxidation, and investment costs are correspondingly cut.

At the same time, the elimination of nitrogen from the system results in a substantial increase in the partial pressure of nitrogen oxides. Therefore, much higher nitric acid concentrations can be attained by absorption than would otherwise be possible.

Miscellaneous Uses for Oxygen

A number of minor uses rounds out the potential of oxygen in the petrochemical industries. Reference has already been made to the one-time production of oxygenated chemicals (methanol, formaldehyde, acetaldehyde) by the partial oxidation of natural gas at McCarthy Chemical Company. Partial oxidation by means of air serves for the production of these and other chemicals at Celanese Corporation's Bishop, Texas, plant.

By-product oxygen is used in the catalytic oxidation of SO_2 at Consolidated Mining and Smelting Company (Trail, B.C.).[16] The advantages over air oxidation are two-fold: (a) the product gas is richer in SO_3. Due to the higher partial pressure of this gas, absorption in sulfuric acid is facilitated. (b) The tail gases from the absorption stage are substantially free of nitrogen and are correspondingly richer in unconverted SO_2. This gas may therefore be recycled to the oxidation stage without too much diluent effect. An increase in yield and a decrease in the SO_2-disposal problem is thereby accomplished.

No plant is known where the improvements in this process have been considered a sufficient basis for the production of oxygen. However, the use of oxygen permits a substantial capacity increase for any sulfuric acid installation and Rush and Downs[17] anticipate eventual wide-spread acceptance of this technique.

In the contact process for sulfuric acid manufacture, oxygen enrichment will cause high temperatures but will also reduce the volumes of gas which must be handled. This permits greater heat recovery and higher thruput. The increase capacity applies especially to the absorber units which benefit from the higher sulfur trioxide content of the product gases. Proper means for heat abstraction must be provided to prevent damage to the catalyst at the higher reaction temperature obtained with oxygen-enriched air.

In chamber plants, the decreased gas volume will greatly boost capacity per chamber. It has been estimated that operation with 30 percent oxygen permits a five-fold increase in thruput over air combustion of sulfur dioxide.

End of part II and series.

NOTE

References appeared at end of Part I.

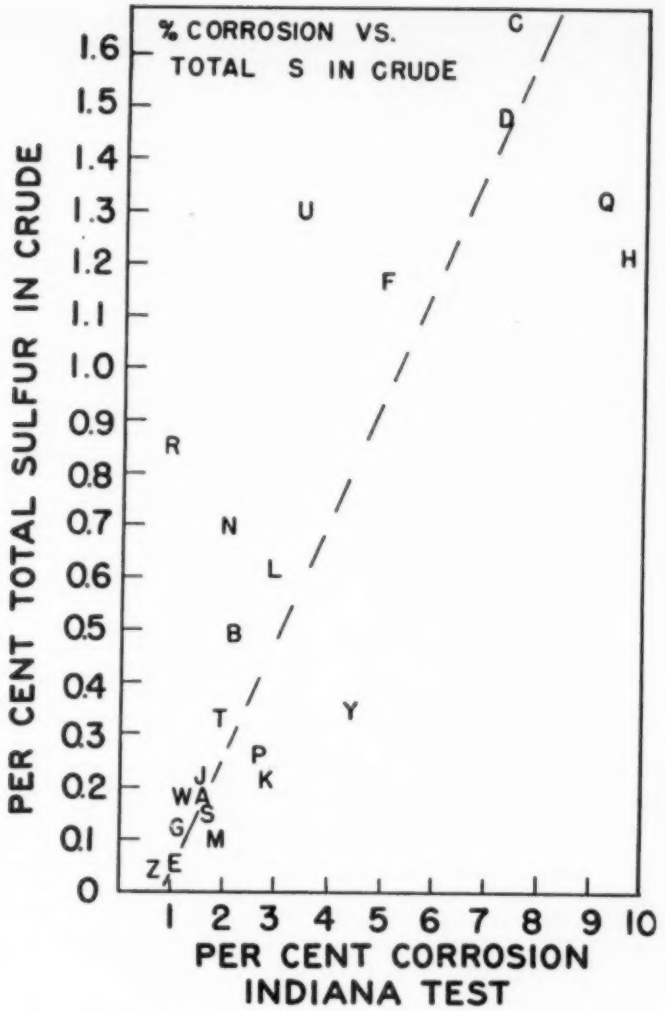

Figure 1. Relationship between percent corrosion and sulfur content of crude, using Indiana method.

Estimating the CORROSIVITY of Crude Oils

An API Committee reports the results of its studies to find an accurate, reliable method for predicting crude oil corrosivity.

H. A. Cataldi,[1] R. J. Askevold[2] and A. E. Harnsberger[3]

SEVERAL YEARS AGO, during one of the meetings of the Subcommittee on Corrosion of the API Committee on Refinery Equipment, the subject of the variation of corrosivity of crude oils in refinery equipment was discussed. One of the points which received attention at that time was the lack of information available to the refiner as to the corrosion which might be expected from a crude oil with which he had not had refining experience. The desirability of having more knowledge as to what may be expected of a crude oil prior to its being refined was recognized. As a result, a subgroup was formed to study the matter, and to attempt to work out a method of evaluation in the laboratory. The subgroup decided its objectives should be as follows:

- Evaluate crude oils from new fields for the purpose of estimating the potential corrosion rates on refinery equipment.
- Reduce refinery corrosion costs by properly protecting equipment from corrosion.
- Furnish the design engineer with a guide for alloy protection of new processing equipment.

A number of agents present in crude oils are responsible for corrosion of refinery equipment. Some of these can be identified, and their effects predicted by known methods. These include determination of the unstable salt content and the determination of organic acids.

Corrosion which may be attributed to sulfur, however, cannot be predicted with certainty from the total sulfur content of the crudes, nor are analytical methods available to differentiate between those sulfur compounds which are harmful and those which are relatively non-reactive. Thus there is indirect evidence that sulfur compounds in different crudes vary considerably in resistance to thermal decomposition.

The efforts of the subgroup have been almost entirely directed to corrosion at elevated temperatures, i.e., at temperatures in excess of 600 F. This paper will present two possible methods of attack. In giving consideration to these methods, it must be borne in mind that we do not hope to arrive at a positive method of establishing the corrosivity of a crude oil to meet all refining conditions. We hope a method can be established whereby a refiner may compare the performance of a

[1] Standard Oil Company (Indiana), Chicago.
[2] The Pure Oil Company, Crystal Lake, Ill.
[3] The Pure Oil Company, Chicago.
This is a condensation of the paper "Estimation of Corrosivity of Crude Oils," presented at the 18th Mid-Year Meeting of API's Division of Refining, New York, May 12, 1953.

known crude against the probable performance of an unknown crude. In other words, if he has been refining a given crude oil or mixture of crudes for a given period of time and has definitely established corrosion rates in various parts of his equipment, we hope to establish the trend which may be expected by a new crude oil or a mixture of crude oils being refined by the use of the same equipment. The same approach could be used to predict the behavior of other charging stocks.

Therefore, it should be emphasized again that it is the objective of this subgroup to develop a practical method of determining only the relative corrosiveness of various crude oils or charging stocks so that the refiner will be able to predict the probable performance of an unknown oil vs. the corrosiveness of an oil with which he has had experience.

"THIS PAPER presents two possible methods of attack. In giving consideration to these methods, it must be borne in mind that we do not hope to arrive at a positive method of establishing the corrosivity of a crude oil to meet all refining conditions. We hope a method can be established whereby a refiner may compare the performance of a known crude against the probable performance of an unknown crude. In other words, if he has been refining a given crude oil or mixture of crudes for a given period of time and has definitely established corrosion rates in various parts of his equipment, we hope to establish the trend which may be expected by a new crude oil or a mixture of crude oils being refined by the use of the same equipment. The same approach could be used to predict the behavior of other charging stocks."

1. The Indiana Method

Principle of Method

Consideration indicated that most of the conventional methods for measuring rapidly the rates of corrosion of steel in such substances as crude oil, such as those concerned with changes in weight, are either tedious or completely infeasible. Although precision weighing techniques may be applied, they are practical only if the amount of attack in a reasonably short exposure time is large and if the scale is intact. If the corrosion is more severe, some of the product is likely to be lost by spalling. The specimen then must be cleaned, without additional loss of metal, before weighing. This may be difficult or impossible. If, in addition, coke deposits on the specimen, the problem of weighing precisely is complicated further.

A method based on the change in the electrical resistance of a specimen, which change results from the loss of metal by exposure to a corrosive medium, would obviate all necessity for cleaning or weighing. Such a method has been described by A. Dravnieks.[1] It is very sensitive and, with it, uniform tarnish thicknesses of the order of one microinch can be measured readily. Furthermore, by the use of a recorder, the corrosion may be followed continuously.

In the method developed by Standard Oil Company (Indiana) for the evaluation of the corrosivity of crude oils, a steel specimen 0.001-inch thick is exposed to a definite volume of the crude oil, in a bomb, for a fixed length of time at a constant temperature and pressure. The amount of corrosion is determined by measuring the electrical resistance of the specimen both before and after the exposure. Inasmuch as the width of the specimen is much greater than its thickness, any changes in width can be ignored; therefore, changes in the electrical resistance are inversely proportional to the thickness. It is implied that the corrosion is uniform, and that the conductivity of the scale is small. Whether these assumptions are reasonable can be checked readily for each different application of the method. Only relative values of voltage and current are measured, making the determination of relative

[1] A. Dravnieks, J. Am. Chem. Soc. 72, 3761 (1950).

TABLE 1

Laboratory and Experimental Corrosion Test Data of Standard Oil Company (Indiana) and Evaluation Summary of Results

Oil Code	CRUDE-OIL DESCRIPTION	SULFUR[1] (PERCENT)		NEUTRALIZATION NUMBER[2]		Corrosion Measured[3] (Percent)	Corrosion Relative to West Texas Crude[4] (Percent)	ASSIGNED DEGREE OF CORROSIVENESS	
		Initial	Final	Initial	Final			From Experimental Data[5]	From Refinery's Data[6]
ZF	Tomball	0.05	0.09	0.74	1.37	0.55	7	Mild	5 percent of West Texas
RE	Van Zandt	0.85	0.93	2.03	0.28	0.76	9	Mild	Mild
GJ	Gulf Coast light	0.12	0.20	1.72	1.71	1.10	13	Mild	Less than HJ
EG	South Sumatra	0.05	0.11	1.10	0.12	1.13	14	Mild	5 to 10 percent of West Texas
WF	West Texas light	0.18	0.34	0.51	1.19	1.30	16	Mild	10 percent of West Texas
JH	Scurry County, Texas	0.20	0.37	0.62	1.14	1.55	19	Moderate	Mild, less than KH
AD	East Texas sweet	0.19	0.36	0.56	0.91	1.55	19	Moderate	2.5 percent of West Texas[7]
SE	Southern Illinois	0.16	0.16	1.05	0.24	1.70	21	Moderate	Mild
MA	Mixed Wyoming	0.11	0.20	0.77	1.14	1.76	21	Moderate	Mild
NB	Ordovician	0.17	0.17	0.78	1.14	1.99	24	Moderate	Mild to extreme,[8] 50 percent of West Texas
BD	West Texas sweet	0.48	0.94	1.07	0.85	2.09	25	Moderate	No data available
TC	Sweet mix of North Texas, Oklahoma and West Kansas	0.38	0.53		0.10	2.34	28	Moderate	Mild to moderate
PB	Pipe line mix of semi-sweet West Texas, Illinois, Oklahoma, East and North Texas	0.26	0.42	0.54	0.91	2.64	32	Severe	Moderate at least
KH	Greenwood and Butler Cos., Kansas	0.22	0.34	1.07	2.05	2.66	32	Severe	More than JH; mild
LA	Rangely, Colorado	0.61	0.94	1.60	0.85	2.92	35	Severe	Severe (3 times MA)
UC	West Texas-New Mexico sour	1.30	1.64		0.13	3.80	46	Severe	Severe
YF	Panhandle	0.35	0.25	0.53	1.76	4.42	54	Severe	80 percent of West Texas
PG	Quiriquire	1.17	1.26	6.82	0.94	4.99	61	Severe	75 percent of West Texas
DG	West Texas	1.48	1.68	1.12	0.77	7.16	100	Extreme	Extreme
CD	West Texas sour	1.67	1.66	1.24	1.08	7.36	100	Extreme	Extreme
QE	Yates, West Texas	1.32	1.24	2.53	0.16	9.01	100	Extreme	Extreme
HJ	West Texas-New Mexico sour	1.21	1.49	1.12	1.36	9.55	100	Extreme	More than GJ

[1] Percent sulfur determined by the quarts-tube method; "initial" values are from whole crude as received; "final" values are from residue left in bomb after test.
[2] Neutralization number determined by titrating colorimetrically to a phenolphthalein end point; "initial" values are from whole crude as received; "final" values are from residue left in bomb after test.
[3] Percent corrosion is percent decrease in specimen thickness as computed directly from change in electrical resistance during the test.
[4] These are rough estimates made relative to the average of the percent corrosion values for the four most corrosive crudes (i.e., for DG, CD, QE, and HJ), and assuming that these four represent 100 percent.
[5] This is an arbitrary classification made in such a way as to be in best agreement with the refinery's estimates.
[6] A more complete summary of the refinery's estimates is given in Appendix hereinafter.
[7] This was a relative rate based upon the use of 4- to 6-percent-chromium tubes.
[8] Higher temperatures and rates of flow and heat transfer made this crude extremely corrosive, although normally it was classed as only mildly corrosive.

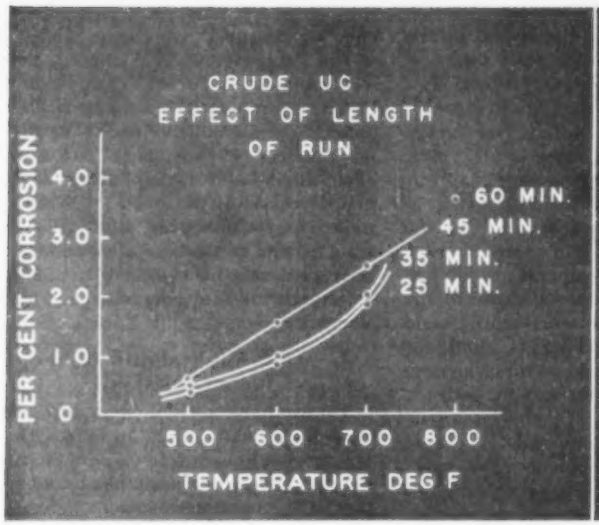

Figure 2. Effect of furnace soaking time and temperature on corrosiveness of Crude "UC."

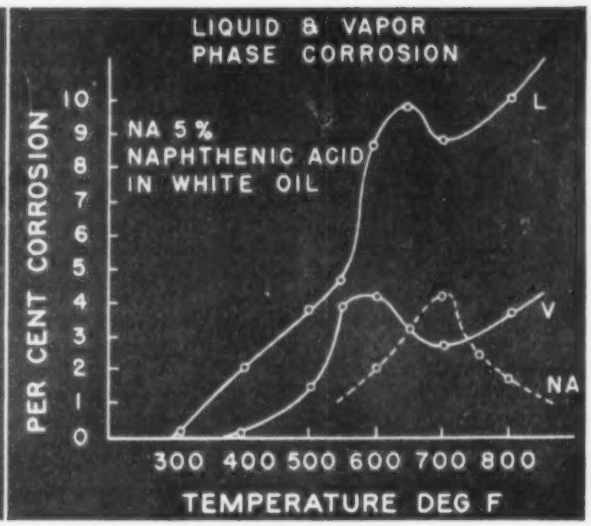

Figure 3. Corrosivity of a naphthenic-base crude oil containing 1.4 percent sulfur.

(or percentage) change of resistance a simple matter. The precision of the electrical measurements is better than 0.1 percent.

Results for the 22 Test Crudes

In Table 1 are shown the results of the laboratory tests performed on the 22 crude oils submitted by the nine cooperating companies. These are coded and arranged in order of increasing corrosivity. The corrosivities are expressed both as percent corrosion (i.e., percent of the test-specimen thickness removed) as determined by the test, and as percent of the average of the worst West Texas sour crudes. For obtaining this latter rating, the percent corrosion values for the four most corrosive crudes, i.e., "DG," "CD," "QE," and "HJ," were averaged and assumed arbitrarily to be 100 percent. The percentage ratings of the other crudes then were calculated relative to this average value. Obviously such a rating at best is a rough one.

One other point, which must be borne in mind when data obtained in short-time tests are analyzed, is that the average rates measured are influenced greatly by the initial rate of attack on clean metal. The results, therefore, are conservative; rates on equipment with accumulated scale and coke can be expected to be lower. Moreover, all laboratory tests have the shortcoming that various plant design factors may affect the actual rates of penetration considerably. This variable is almost impossible to evaluate in any tests.

Effect of Various Factors on Corrosiveness

Sulfur and Acidity. Table 1 also shows the results of analyses for total sulfur and for acidity (neutralization number) for each oil, made both before (on the whole crude oil) and after (on the residue left in the bomb) the corrosion test runs. In Figure 1 the original sulfur content is plotted against the percent of corrosion found by the Indiana test. As expected, most of the oils, within broad limits, indicate an increase of corrosion with increasing sulfur content. Thus, in the usual case, unstable sulfur compounds seem to account for most of the corrosion. A few oils, however, lie significantly outside the band. For instance, oils "FG," "RE," "NB," and "UC" show less corrosion than might be expected from the sulfur content; whereas oils "HJ," "QE," and "YF" show more.

No apparent correlation was found between the change in the sulfur content of the oil during the test and the corrosiveness. One might suspect such a relation if the corrosion were mainly caused by thermally unstable sulfur compounds. However, the lack of correlation with sulfur content might be explained by the presence in some crudes of considerable amounts of volatile, although non-corrosive, sulfur compounds.

Similarly, no relation was found between neutralization number and corrosiveness.

Pressure. The effect of pressure (in the range of atmospheric to 120 psig) was variable. In some crudes the corrosion was a sensitive function of the pressure; in others the effect was slight. This indicates that the corrosive constituents were distributed differently, i.e., according to volatility, in the oils.

Duration of Run and Aging. Figure 2 shows the results obtained when the length of a run (i.e., the total time in the furnace) was increased from 25 min. to 60 min. It is clear that the amount of corrosion tends to approach a constant value for each temperature, as would be expected from a batch test.

Table 2 shows the effects of aging at room temperature on the corrosiveness of an arbitrarily chosen crude oil. The corrosivity of this oil increased as it aged in the container. After four months of aging its corrosivity at 800 F. had increased to about 2½ times its corrosivity when first received. This may be the result of oxidation, or of some other less obvious change in the oil. Such an effect may have a significant bearing on the apparent discrepancies in the laboratory results found in the case of some of the oils.

TABLE 2

Effect of Aging at Room Temperature on the Corrosiveness of a Crude Oil

(Each number indicates the result of a separate Indiana corrosion test, i.e., percent corrosion)

Temperature of Test (Fahrenheit)	Time After Initial Test (Months)			
	0	1	3	4
400			0.9	1.3
			0.7	1.0
500			0.8	1.3
			1.1	1.4
600			1.5	2.0
			1.6	1.6
700			3.5	5.4
			3.0	2.9
800	1.6	2.4	4.7	5.4
	1.8	2.3		4.4
	1.9			
	1.8			
	1.7			
	2.0			

Vapor-Phase Corrosion

By the use of a pyrex tube as a spacer, a few tests were run in which

a second specimen was suspended in the space above the normal liquid level in the bomb; and thus evaluations of the liquid-phase corrosivity and the vapor-phase corrosivity were secured simultaneously. The results of some runs in which this was done are shown in Figures 3 and 4. Curves for liquid-phase and vapor-phase corrosion are shown in Figure 3 in comparison with a liquid-phase corrosion curve obtained on a white oil (essentially non-corrosive) to which 5 percent of naphthenic acid is added. The peaks in the three curves illustrate the characteristic corrosion effects frequently found with crudes which contain naphthenic acids.

In some instances, larger deviations were found in vapor-phase measurements than in liquid-phase measurements. These deviations may have been the result of "splashing" effects, although there is no definite evidence that such boiling effects exist. However, inasmuch as the bottom of the vapor specimen is only 3½ inches to 4 inches above the liquid level, "splashing" may be important.

The curve in Figure 3 is interesting because it is believed to show the combined effects of naphthenic acids and sulfur. Up to about 550 F., corrosive components apparently tend to appear in the vapor, so that the vapor-phase corrosivity increases rapidly. At about 550 F. these corrosive vapors probably are lost to the system by the venting required to maintain the pressure between 80 psig and 90 psig. As a result, the vapor corrosivity first drops, and then shows a normal rise again as other corrosive components (most probably sulfur compounds) appear in the vapor because of cracking at these higher temperatures. In the liquid phase there is a sharp increase in corrosivity at temperatures of 550 F. to 650 F.—perhaps because of the formation of new non-volatile acid compounds by cracking. It should be noted that this peak is superimposed on the normal increasing corrosion curve which most probably is attributable to sulfur compounds. At 700 F. these new acid compounds presumably have boiled off, and the corrosion rate then follows the normal high-sulfur curve again. The liquid-phase corrosivity of a 5-percent solution of Aruba naphthenic acid in a highly refined white oil (which has been found to be essentially non-corrosive) also is shown for comparison. This illustrates the effect of temperature and the volatility of the corrodant on the rate of reaction. There is a sharp peak in this curve at 700 F. At 650 F. and 750 F. the corrosion rates are, respectively, 25 and 35 percent lower than at this maximum. The conclusion seems unavoidable that this peak is a direct effect of the added naphthenic acids.

The data plotted in Figure 4 also were obtained on a high-sulfur crude which was reported to contain sizable amounts of naphthenic acids. There is no evidence of any peak corrosion effect attributable to naphthenic acids in this curve. In this case—for some reason as yet unknown, although possibly related to the type of naphthenic acids present—this characteristic effect of naphthenic-acid corrosion was not found.

General Applicability of the Indiana Method

The Indiana method also may be used for investigating the corrosivity of various liquids and vapors in refinery streams. It already has been employed to investigate various refinery corrosion problems which resulted from hot oils, from acids, and from other aqueous media at ambient and elevated temperatures. The method gives a direct measure of the amount of corrosion, whatever its cause. However, the results must be interpreted with due regard to possible effects of the relative volatilities of the components of the oil under the test conditions used.

ACKNOWLEDGMENT

The assistance received from Dr. Carl H. Samans and Dr. Andrew Draviniks, both in setting up the test procedure and in evaluating the data, and from R. S. Cheney for suggestions regarding the statistical treatment of the data is gratefully acknowledged.

2. Pure Oil Method

The prediction of corrosion rates to be expected upon processing a given crude oil is complicated by the fact that corrosion may be caused by several different agents. Direct measurement of corrosion rates is an attractive

TABLE 3

The Pure Oil Company Data on Known Crude Oils

Crude Oil	Corrosion Experienced in Refining	Sulfur Content (Percent by Weight)		Hydrogen Sulfide Released from Topped Crude (Grams per 100 Ml)				
		Whole Crude	Topped Crude	900 F.	850 F.	800 F.	750 F.	700 F.
Van Zandt	Mild	0.86	1.23	Nil	Nil			
Illinois	Mild	0.17	0.22	0.0016	0.0012	Nil	Nil	Nil
Yates	Extreme	1.37	1.59	0.0375	0.0197	0.0013	Trace	Nil
		1.44	1.89	0.0666	0.0440	0.0162	0.0136	

TABLE 4

Experimental Corrosion Test Data of The Pure Oil Company and Evaluation Summary of Results

Oil Code	CRUDE-OIL DESCRIPTION	SULFUR CONTENT (Percent by Weight)		Hydrogen Sulfide Released at 850 F. (Grams Per 100 Ml)	Percent Hydrogen Sulfide Released Relative to West Texas Crude	ASSIGNED DEGREE OF CORROSIVENESS	
		On Crude	On Topped Crude			From Experimental Data	From Refinery's Data
RE	Van Zandt	0.86	1.23	Nil	Less than 1.0	Mild	Mild
LA	Rangely, Colorado	0.63	1.02	Nil	Less than 1.0	Mild	Severe (3 times MA)
MA	Mixed Wyoming	0.15	0.23	Nil	Less than 1.0	Mild	Mild
ZF	Tomball	0.10	0.20	Nil	Less than 1.0	Mild	5 percent West Texas
EG	South Sumatra	0.14	0.23	Trace	Less than 1.0	Mild	5 to 10 percent West Texas
AD	East Texas sweet	0.27	0.46	Trace	Less than 1.0	Mild	2.5 percent West Texas
GJ	Gulf Coast light	0.16	0.25	0.0006	1.1	Mild	Less than HJ
SE	Southern Illinois	0.17	0.22	0.0012	2.2	Mild	Mild
JH	Scurry County, Texas	0.24	0.49	0.0019	3.4	Mild	Mild (less than KH)
BD	West Texas sweet	0.53	0.81	0.0033	6.0	Mild	*
PB	Pipe line mix of semi-sweet West Texas, Illinois, Oklahoma, and East and North Texas	0.29	0.52	0.0035	6.3	Mild	Moderate at least
KH	Greenwood and Butler Counties, Kansas	0.26	0.39	0.0045	8.1	Mild	Mild (more than JH)
WF	West Texas light	0.24	0.43	0.0047	8.5	Mild	10 percent West Texas
TC	Sweet mix of North Texas, Oklahoma, and West Kansas	0.47	0.65	0.0073	13.2	Mild	Mild to moderate
NB	Ordovician	0.21	0.35	0.0115	20.8	Moderate	50 percent West Texas
UC	West Texas-New Mexico sour	1.52	2.15	0.0262	47.5	Severe	Severe
HJ	West Texas-New Mexico sour	1.24	2.00	0.0359	65.0	Severe	Severe (more than GJ)
FG	Quiriquire	1.31	1.42	0.0392	71.0	Severe	75 percent West Texas
QE	Yates, West Texas	1.44	1.89	0.0440	100	Extreme	Extreme
DG	West Texas	1.76	1.93	0.0475	100	Extreme	Extreme
YF	Panhandle	0.37	0.53	0.0478	100	Extreme	80 percent West Texas
CD	West Texas sour	1.76	2.01	0.0818	100	Extreme	Extreme

* Data not available. † Mildly corrosive in one unit, and extremely corrosive in a similar unit which has higher rates of flow and heat transfer.

solution; but, for a small-scale bench test, conventional corrosion measurements do not have sufficient sensitivity to detect the minute amount of corrosion which occurs in small samples over short time periods. The highly interesting technique developed by Standard Oil Company (Indiana) overcomes this difficulty very nicely.

Our attention has been directed more specifically to the corrosive effect of sulfur compounds, particularly under conditions of high temperature and pressure. The corrosive action resulting from other agents such as, for example, unstable inorganic chlorides, can be predicted with a fair degree of certainty, and means are usually available to counteract the effect. On the other hand, although corrosive action often is proportional to sulfur content, there are so many exceptions that total sulfur content of a crude oil cannot be relied upon as a measure of corrosivity. Accordingly, it was decided that some measure of the relative activity of sulfur in various crude oils was necessary.

THEORY. It does not seem likely that sulfur compounds, as such, combine directly with metals in the corrosion process, but, instead, that they first start to decompose; the sulfur attacks metals during or after this decomposition. It is known that the temperatures at which various sulfur compounds begin to decompose rapidly vary widely with the compound. Inasmuch as it is not yet practicable to measure each of the many sulfur compounds present in crude oils, it is easier to measure either the threshold temperature where decomposition commences, or to measure the degree of decomposition at some given temperature. In connection with this latter measurement it was postulated further that, inasmuch as metal sulfide is the product of corrosion, the corrosive agent must be a "nascent" sulfide group and that, if no susceptible metal were present to form the sulfide, then this "nascent" sulfide would capture hydrogen to form hydrogen sulfide—and the latter can be measured.

Based on this reasoning, experiments were carried out to measure the quantity of hydrogen sulfide released from various crude oils at different temperatures. There is no assumption that the hydrogen sulfide itself is the corrosive agent but, instead, that it is merely a measure of the momentarily corrosive sulfur atoms which result from the breakdown of the parent sulfur compound. It would be expected that, in an environment where metals were being actively corroded, the release of hydrogen sulfide would be diminished by the amount of metallic sulfide being formed.

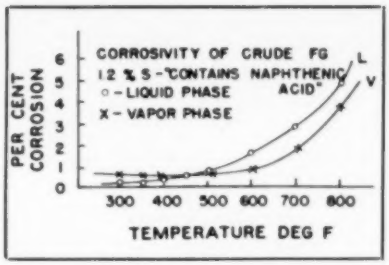

Figure 4. Liquid and vapor phase corrosivity of Crude "FG."

EXPERIMENTAL. Three crude oils upon which long refining experience had given a very reliable picture of corrosiveness were chosen to test this reasoning. These were first topped to 500 F. to remove gasoline and dissolved hydrogen sulfide; then they were subjected to very rapid heating to a series of different temperature levels and held at these levels for short periods of time, and the evolved hydrogen sulfide was measured in each case. These results are shown in Table 3. From examination of these data it was decided that 850 F. gave results which correlated best with known refinery corrosion experience on these three crude oils.

RESULTS. Experimental conditions having been established whose results correlated with the three known crude oils, the same test was then applied to each of the crude oils of then unknown corrosion behavior which had been submitted by members of the Subcommittee on Corrosion of the API Committee on Refinery Equipment. The hydrogen sulfide evolved for each crude oil is expressed as grams per 100 ml on the topped crude, and also as percent of that evolved from West Texas sour crude oil, the most corro-

TABLE 5
Results of Indiana Corrosivity Test Runs with Derived Data for Evaluating Significance and Repeatability of Results

Oil Code	Crude-Oil Description	Indiana Corrosivity Test Results, Percent Corrosion Measured[1]	Geometric Mean of Corrosivity Test Results	Ratio[2]	Least Significant Ratio[3]	Corrosivity Rating
ZF	Tomball	0.3; 0.8	0.55	....	....	Mild
RE	Van Zandt	0.9; 0.7; 0.6; 0.9	0.76	....	....	Mild
GJ	Gulf Coast light	1.0; 1.2	1.10	1.44[4]	1.28	Mild
EG	South Sumatra	1.1; 1.7; 0.9; 1.0	1.13	1.03	1.28	Mild
WF	West Texas light	1.4; 1.2	1.30	1.15	1.28	Mild—moderate
JH	Scurry County, Texas	1.4; 1.7	1.55	1.19	1.32	Mild—moderate
AD	East Texas	1.6; 1.5	1.55	1.00	1.32	Mild—moderate
SE	Illinois	1.7; 1.7	1.70	1.10	1.32	Mild—moderate
MA	Mixed Wyoming	1.7; 1.8	1.76	1.04	1.32	Mild—moderate
NB	Ordovician	2.2; 1.4; 2.1, 2.1; 2.3	1.99	1.13	1.27	Moderate
BD	West Texas sweet	2.1; 2.1	2.09	1.05	1.27	Moderate—severe
TC	Sweet mix of North Texas, Oklahoma, W. Kansas	2.4; 2.3	2.34	1.12	1.32	Moderate—severe
PB	Semi-sweet West Texas plus Illinois, Oklahoma, East and North Texas	2.1; 2.9; 2.7; 2.8; 2.6; 2.8	2.64	1.13	1.26	Moderate—severe
KH	Greenwood and Butler Counties, Kansas	2.8; 2.5	2.66	1.01	1.26	Moderate—severe
LA	Rangely, Colorado	2.8; 3.0	2.92	1.10	1.32	Moderate—severe
UC	W. Texas-New Mexico sour	3.9; 4.2; 3.6; 3.2	3.80	1.30[4]	1.28	Severe
YF	Panhandle	4.3; 4.6	4.42	1.16	1.28	Severe
FG	Quriquire	5.3; 6.4; 3.9; 4.4; 5.3; 5.4	4.99	1.13	1.26	Severe
DG	West Texas	5.8; 8.1; 7.7; 7.1; 7.3; 7.3	7.16	1.44[4]	1.18	Extreme
CD	West Texas sour	7.4; 7.2	7.36	1.03	1.26	Extreme
QE	Yates, West Texas	8.8; 9.2	9.01	1.22	1.32	Extreme
HJ	W. Texas-New Mexico sour	10.4; 8.8	9.55	1.06	1.32	Extreme

[1] Each number is for a separate test run.
[2] This is the ratio between the geometric mean corrosivity value for each oil and the geometric mean corrosivity value for the oil immediately preceding it in the table. Inasmuch as crude ZF was not considered because its corrosivity was so small, no ratio can be shown for crude RE because it is, in effect, not preceded by another oil; i.e., it is "first" in the table.
[3] The values of the least significant ratio depend on the number of tests run on each oil, and are computed as shown and tabulated as follows:

Values of Least Significant Ratio at the 95 Per Cent Significance Level (t_{95}) for Various Values of N_1 and N_2 (Number of Tests on Any Two Oils, "A" and "B," Respectively)

	OIL "A," N_1					
OIL "B," N_2 Number of Tests On:	1	2	3	4	5	6
1	1.49	....	....	....	....	....
2	1.41	1.32	....	....	....	....
3	1.38	1.30	1.26	....	....	....
4	1.37	1.28	1.24	1.22	....	....
5	1.36	1.27	1.23	1.21	1.20	....
6	1.35	1.26	1.22	1.20	1.19	1.18
∞	1.32	1.22	1.18	1.15	1.13	1.12

$$LSR = t_{95}\left(\frac{1}{N_1} + \frac{1}{N_2}\right)^{1/2}$$

a. A "95 percent significance level" means that, considering all cases in which the two oils actually are the same, in 95 percent of the cases they will be called the same, and in 5 percent of the cases a non-existent difference will be reported.
b. For the series of tests covered in this paper 5 was calculated to be 0.27 on the basis of a log10 normal distribution of repeatability.
[4] These three ratios are the only ones larger than the corresponding least significant ratios and hence, indicate the only three places in the table where there is a significant gap; i.e., before, respectively, crudes GJ, UC, and DG.

sive oil examined in this series. These results are shown in Table 4, together with corrosion histories which have since been reported by each refiner. These latter data have been translated into a scale of four adjectives which describe corrosiveness ranging from "mild" to "extreme." For comparison, the numerical results were then empirically translated into these same adjectives; and it will be seen that, with one outstanding exception, viz., that of Rangely crude oil, predicted corrosiveness is in reasonably good qualitative agreement with refining experience. This exception may be the result of the action of other corrosive agents, although salt content and organic acid content are not outstandingly different for this oil.

ACKNOWLEDGMENT

The author of this section wishes to express his grateful appreciation to N. W. Lambert, of The Pure Oil Company Research and Development Laboratories, for his having carried out the experimental work described.

Conclusion

It is the opinion of the subgroup that the foregoing results are sufficiently encouraging to warrant further work on the subject. Toward this end participation within the industry is invited—with the hope that further application of the foregoing methods will be tried and the data reported, and that improvements of the methods will be developed. We also invite other methods of attacking the problem. The primary purpose of making this information available to the industry is the hope that it will stir the imagination of those who deal with these problems, and that, as a result, a workable method of determination of the corrosivity of crude oils will be forthcoming.

APPENDIX

REFINERY DATA SUMMARY

Code		
AD	Description	*East Texas sweet.*
	Rates	Not available on low-carbon steel.
	Materials	Thermal cracker.
		Tubes: 4 to 6 percent chromium, 0.5 percent molybdenum (0.001 inch per 1,000 hours).
	Comments	Corrosivity toward 4 to 6 percent chromium is 2.5 percent of West Texas.
		Agrees with Pure's finding.
BD	Description	*West Texas sweet.*
	Comments	Oil not segregated.
CD	Description	*West Texas sour.*
	Rates	Not available on carbon steel.
	Materials	Thermal cracker: 900 F.; 700 psi.
		Tubes: 4 to 6 percent chromium, 0.5 percent molybdenum (0.04 inch per 1,000 hours).
		Need tubes of: 7 to 9 percent chromium, 0.5 percent molybdenum.
	Neutralizers	None.
	Comments	Might be some erosion.
		Corrosion by unstable sulfur compounds.
DG	Description	*West Texas*
	Rates	$\frac{1}{16}$ ipy* below 600 F.
		$\frac{1}{16}$ to $\frac{1}{8}$ ipy at 600 to 700 F.
		$\frac{1}{8}$ to $\frac{1}{4}$ ipy at 700 to 750 F.
		$\frac{1}{4}$ to 1 ipy above 750 F.
	Materials	Thermal cracker.
		Tubes at 1,040 F.
		Type 304 (18-8) no loss; type 501 showed 0.01 to 0.05 ipy in radiant section.
		Atmospheric distillation.
		Type 501 tubes lose 0.007 ipy.
		Carbon-steel tubes lose 0.3 ipy.
	Neutralizers	Sodium carbonate only in atmospheric feed.
	Comments	Corrosion due to sulfur at high temperatures.
		Adjectival findings correct.
EG	Description	*South Sumatra.*
	Rates	$\frac{1}{16}$ ipy at 400 F.
		$\frac{1}{16}$ ipy at 200 F.
		$\frac{1}{16}$ ipy at 460 F.
	Materials	Thermal cracker.
		Tubes at 600 F. to 1,000 F.
		Type 304 for strength. No corrosion.
		Soakers: Carbon-steel; no corrosion at 900 F.
	Neutralizers	None.
	Comments	Low sulfur; high salt. Adjectival laboratory findings correct.
		Relative to West Texas corrosivity is 5 to 10 percent (estimated).
FG	Description	*Quriquire.*
	Rates	2/32 ipy at 650 F.
		2/32 ipy at 700 F.
		Nil at 400 F.
	Materials	Thermal cracker tubes:
		870 F; 500 psi.
		Type 501 (5 percent chromium, 0.5 percent molybdenum) in radiant section, ten-year life.
		Carbon steel in convective section, 4.5-year life.
		Soak drums:
		870 F.; 475 psi.
		Type 304 (18-8) lined.
		Some units gunited.
		Type 412 (12 percent chromium) corrodes at 4/64 ipy.
	Neutralizers	None.
	Comments	Naphthenic acids cause severe corrosion at 450 F. in bubble tower.
		Rate for type 317 (18 percent chromium, 10 percent nickel, 3 percent molybdenum) is 0.002 ipy.
		Estimated sulfur corrosivity, 75 percent of West Texas.
		Adjectival test findings correct.
GJ	Description	*Gulf Coast light.*
	Rates	Thermal cracker charging 20 to 50 percent of crude GJ plus low-sulfur constituents.
		Carbon-steel specimens.
		Gas-oil pump: 700 F. (0.062 ipy).
		Still top, vapors: 890 F. (0.002 ipy).
		Residuum pump: 765 F. (0.093 ipy).
	Comments	Less corrosive than crude HJ.
		Crudes not segregated.
HJ	Description	*West Texas-New Mexico sour.*
	Rates	Atmospheric distillation unit charging mostly crude HJ.
		Crude-heater outlet: 590 F. (0.072 ipy).
		Reduced crude: 545 F. (0.001 ipy).
		Topped-crude vapor: 500 F. (0.013 ipy).
		Vacuum section to 760 F.; rates up to 0.055 ipy.
		Some specimens disintegrated
		Thermal cracker charging 10 to 60 percent of crude HJ plus high- and low-sulfur constituents.
		Pump: black oil; 830 F. (0.011 ipy).
		Heater: black oil; 400 F. (0.024 ipy).
		Vapor space: 780 F. (0.060 ipy).
	Comments	More corrosion than crude GH.
		Not segregated.
JH	Description	*Scurry County, Texas*
	Comments	Mildly corrosive. Less than crude KH.
KH	Description	*Greenwood and Butler Counties, Kansas.*
	Comments	Mildly corrosive. Slightly more corrosive than crude JH.
LA	Description	*Rangely, Colo.*
	Rates	Not available. About 3 times as corrosive as Lance Creek (crude MA).
	Material	Thermal cracker.
		4 to 6 percent chromium and type 420 steels.
MA	Description	*Fiddler, Lance, and Mush Creek, Wyo., crude mixture.*
	Rates	Not available—mildly corrosive.
	Material	Thermal cracker: 960 F. (265 pound).
		Tubes:
		4 to 6 percent chromium; no corrosion.
		2 percent chromium; not satisfactory.
		Reaction chamber:
		Carbon-steel sides protected by coke.
		Top coated with type 420 steel.
		Flash tower: carbon steel except for type 420 steel, coated top.
		Heat exchanger: 4 to 6 percent chromium with type 420 steel heads.
		Vacuum flash; carbon steel ($\frac{5}{8}$ inch in six years).
	Comments	Little erosion or corrosion by sulfur.
		Mildly corrosive, about one-third as corrosive as crude LA.
NB	Description	*Ordovician (West Texas—0.2 percent sulfur).*
	Materials	Furnace tubes: carbon steel gave unexpectedly high loss.
	Comments	Oil which previously had given no trouble resulted in perforated tubes in new unit within a year. New unit has higher rates of flow and heat transfer, and higher temperature. Estimated corrosivity now is 50 percent of West Texas sour. Laboratory results, therefore, give only half the picture; therefore, corrosivities should be multiplied by 2.
PB	Description	*Mixture of 42 percent semisweet West Texas, 18 percent Illinois, 35 percent Oklahoma, and balance East and North Texas*
	Rates	Carbon-steel tubes:
		350 to 460, 0.002 inch per 1,000 hours.
		460 to 500, 0.003 inch per 1,000 hours.
		500 to 600, 0.004 inch per 1,000 hours.
		600 to 700, 0.017 inch per 1,000 hours.
	Comments	At temperatures of 600 F. and higher corrosion is moderate at least. Tube replacements are low-chromium steel. Transfer line to atmospheric tower will be low-chromium steel. Alloy tubes used in high-temperature and high-pressure units.
QE	Description	*Yates, West Texas.*
	Rates	Steel satisfactory below 500 F.
		Above 900 F. economical to use 18-8 (type 304) for process piping.
		Furnace tubes: 5 to 9 percent chromium.
	Neutralizers	None.
RE	Description	*Van Zandt.*
	Materials	Distillation units: carbon steel generally satisfactory.
		Fractionating trays in the 500- to 600-F. zone have used type 304, stainless (18-8).
	Comments	Only serious difficulties encountered are in distillation because of the presence of agents other than sulfur. Corrosion under cracking conditions considered mild.
SE	Description	*Southern Illinois.*
	Rates	Corrosion to carbon steel: average $\frac{1}{16}$ ipy.
		Maximum rate: $\frac{1}{8}$ ipy above 800 F.
	Materials	2 to 5 percent chromium where economical.
	Comments	Mild corrosion believed due to sulfur at high temperatures.
TC	Description	*Sweet mix of North Texas, Oklahoma, and West Kansas*
	Rates	Thermal cracker furnace:
		Light gas oil, 0.4 percent sulfur.
		650 F. to 970 F.; 750 psi to 1,100 psi.
		0.02 ipy to 0.21 ipy.
		Atmospheric furnace:
		Crude, 0.18 to 0.25 percent sulfur.
		350 F. to 750 F.
		0.003 ipy to 0.005 ipy.
	Comments	Present crude: 0.25 to 0.40 percent sulfur.
		Mildly corrosive before increase in sulfur.
UC	Description	*West Texas-New Mexico sour. 1.00 to 2.0 percent sulfur.*
	Rates	Atmospheric furnace:
		420 to 570 F.
		0.02 ipy to 0.03 ipy.
	Comments	Severely corrosive.
WF	Description	*West Texas light.*
	Comments	Estimated corrosivity, 10 percent of West Texas sour.
YF	Description	*Panhandle.*
	Comments	Estimated corrosivity, 80 percent of West Texas sour.
ZF	Description	*Tomball.*
	Comments	Estimated corrosivity, 5 percent of West Texas sour.

* Inches per year.

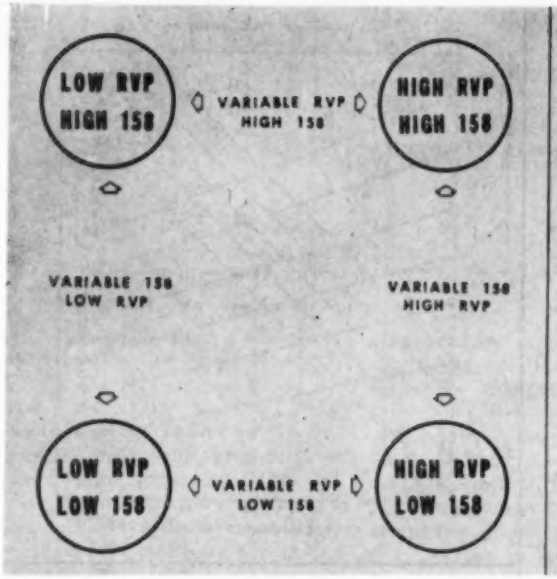

Figure 1. Blending characteristics of test fuels: Vapor lock.

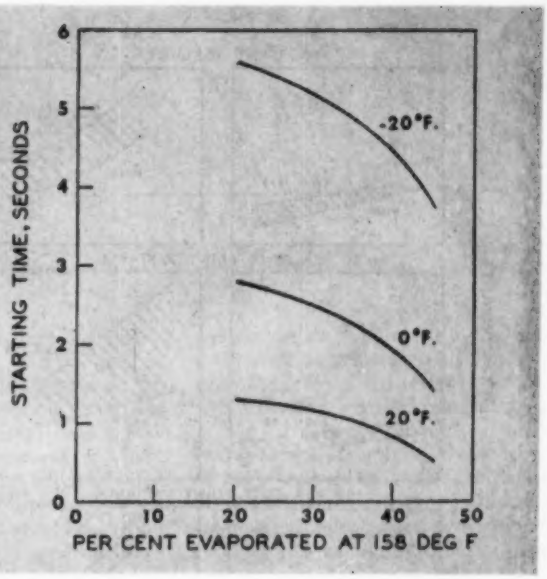

Figure 2. Effect of volatility and temperature on starting time.

Volatility Sets Automobile Performance

Latest test results show the effects of volatility on:

- **Starting**
- **Warmup**
- **Vapor Lock**

C. J. Domke, C. B. Tracy and H. R. Taliaferro
Standard Oil Company (Indiana)
Whiting

VOLATILITY IS a gasoline property at least as important as octane number but not so easily evaluated. Anti-knock quality has received constant attention because the motorist easily recognizes engine knocking. He also easily recognizes slow starting and warmup and vapor locking—this discussion shows the relationship of gasoline volatility with these properties. A quality motor gasoline must provide easy starting and rapid warmup of the engine without vapor lock or other difficulties.

Volatility is a vapor-forming characteristic that varies with temperature, and is usually measured by standardized vapor-pressure and distillation tests.[2a] Few of the public are aware that gasoline volatility is carefully controlled to suit the climate and season. Customer-acceptance tests indicate that users can recognize differences in starting and warmup time among motor fuels.

Easy starting and rapid warmup are provided by high volatility, and were experimentally studied by the authors' co-workers before World War II. Holaday[7] conducted similar studies, and Moxey[10] carried out warmup tests on postwar cars in 1946. As a result of these investigations the volatility factors affecting starting and warmup are well understood for prewar and early postwar cars.

Vapor lock results from excessive volatility, and has long been the object of much study. Recent work includes the Pawhuska and Nowata[11] road tests and the Coordinating Research Council, Inc., tests at Indio.[4]

In 1949 several automotive developments and design changes suggested a re-evaluation of gasoline-volatility requirements. Engines of new design were introduced by some manufacturers. The use of automatic transmissions was extended, and several new types were introduced. The use of automatic chokes had increased; only a few 1949 models had manual chokes. Furthermore, body styles had changed, and the cooling of fuel-system components might be different from that in earlier cars.

An experimental program begun in 1949 has demonstrated the relation between gasoline volatility and the starting, warmup, and vapor-locking performance of postwar passenger cars. The performance of selected automo-

TABLE 1
Design Characteristics Of Test Cars

Car	Valve Arrangement	Transmission Design	Type of Choke
A	Overhead	Torque Converter	Automatic
B	Overhead	Manual	Manual
C	Overhead	Automatic	Automatic
D	L-Head	Manual	Manual
E	L-Head	Manual	Automatic
F	L-Head	Manual	Automatic

Original presentation as "Effect of Gasoline Volatility on the Performance of Passenger Cars" was before the 18th Mid-Year meeting of the American Petroleum Institute's Division of Refining, New York, May 12, 1953.

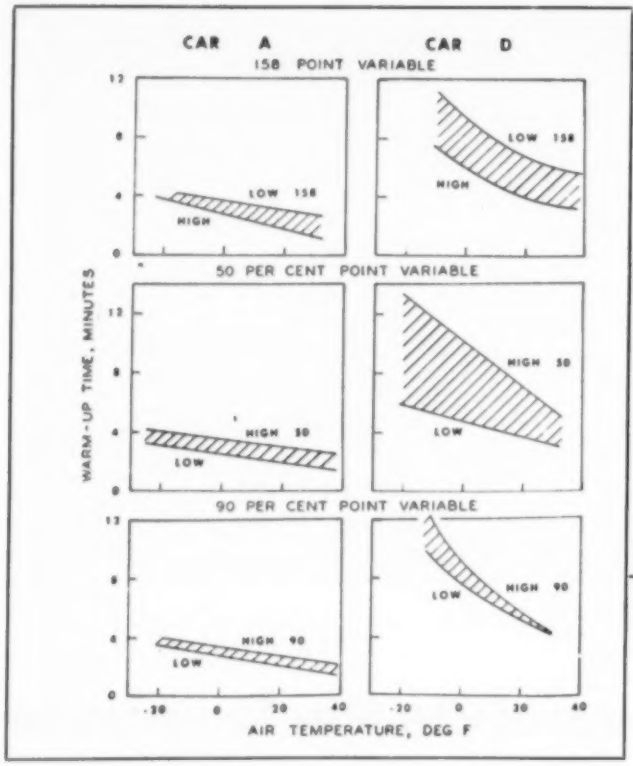

Figure 3 (left). Effect of car design on warmup time.

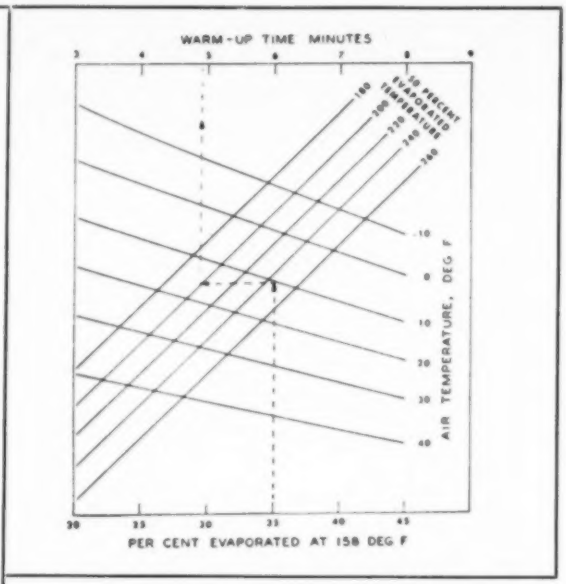

Figure 4. Warmup time: Average of cards D, E and F (Directions: Draw line from percent evaporated at 158 F. to air temperature to 50 percent evaporated temperature to warmup time).

biles was studied during operation with especially blended motor fuels.

Experimental

Six test cars were chosen on the basis of large sales volume and postwar changes in engine or transmission design which might affect gasoline-volatility requirements. Pertinent design characteristics of these cars are given in Table 1. The six cars were of popular makes, representing about 70 percent of total car sales in 1949.

The effects of gasoline volatility on starting and warmup were determined in tests carried out during the winter of 1949-50. To cover the desired temperature range, the work was conducted at Moorhead, Minn., from —30 to 30 F., and at Whiting, Ind., from 0 to 40 F. The test gasolines were blended to study the effects of three points on the ASTM distillation curve. These were the percent evaporated at 158 F., or the 158 point,[6] and the temperatures at which 50 and 90 percent were evaporated, or the 50 and 90-percent points. As shown in Table 2, three sets of test gasolines were prepared so that in each set one of the three points was varied, whereas the other two were held constant. In other respects the gasolines were blended to resemble commercial motor fuels. In addition to studies of the three specified points on the distillation curve, correlations of performance were attempted for the 10, 20, 30, and average 65-percent points.

In the work on starting the test method used was *Coordinating Research Council Procedure F-6-943.*[5] Manufacturers' recommendations were followed in varying the viscosity of the crankcase oil with ambient temperature. Starting time is the number of seconds from initial engagement of the starter until the engine's first fire. If there was no fire in 10 seconds, cranking was discontinued and the gasoline was rated as failing.

In the work on warmup the method of Taylor and Gibson[12] was used. Warmup time is the number of minutes needed for satisfactory acceleration without engine bucking or backfiring. Temperatures were measured at several points in the engine in the hope of correlating them with warmup time.

The effects of gasoline volatility upon vapor lock were determined in tests conducted from 50 to 95 F. at Whiting, Ind., and Texas City, Texas, in 1950. Additional tests were made at 85 to 115 F. near San Bernardino, Calif., in 1952. As diagrammed in Figure 1, blends of four base gasolines allowed investigation of the effects on vapor lock of the 158 point and vapor pressure independently or in combination. Motor fuels could be blended having any Reid vapor pressure and 158 point within the limits of the base fuels. The test procedure consisted of a high-speed stabilization run, a 15-minute soaking period, and a high-gear full-throttle acceleration to 70 mph. Uneven performance during the acceleration was rated as incipient vapor lock.

TABLE 2

Distillation Characteristics of Test Fuels Starting And Warm-Up

Evaporated at 158 °F. Percent	Temperature at 50% Evaporated °F.	Temperature at 90% Evaporated °F.
17 to 44	Constant at 235	Constant at 340
Constant at 35	186 to 258	Constant at 340
Constant at 35	Constant at 245	303 to 404

Results and Discussion

The 158 point provided a more consistent measure of starting time than the 10, 20, or 30-percent points. Figure 2 shows starting time as a function of the 158 point at three air temperatures. All test cars showed similar starting characteristics. Because of the effect of temperature on battery output and on the viscosity of the oils in the engine and transmission, the range of winter air temperatures has more effect on starting time than do practical changes in volatility.

A greater variation between the cars was noted in warmup time. The effects of motor-fuel volatility and air temperature on the warmup of two cars are given in Figure 3. Car "A" was insensitive to wide changes in both gasoline volatility and air temperature, whereas car "D" was sensitive to

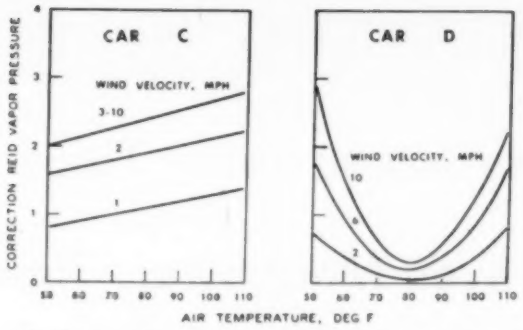

Figure 5.—Correction for effect of wind velocity on Reid vapor pressure for incipient vapor lock.

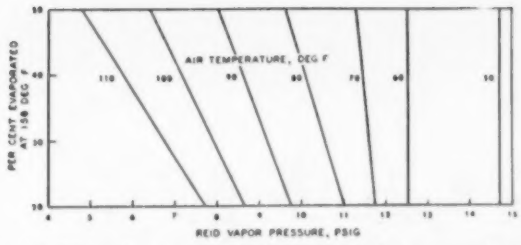

Figure 6. Effect of vapor pressure, 158 point, and air temperature on incipient vapor lock: Composite, critical cars (Rvp corrected to 5-mph wind).

changes in both. The 90-percent point had little influence on warmup in any of the cars. There is no direct relation between engine temperatures and warmed-up performance which can be applied to all cars. Cars "B" and "C" were also sensitive only to changes in air temperature. The rates of warmup for cars "D," "E," and "F" varied with both air temperature and volatility, and could be related to the ASTM distillation curve in terms of the 158 point and the 50-percent point. Figure 4, an average of the data obtained on Cars "D," "E," and "F," can be used to estimate the warmup performance of any gasoline.

Because vapor lock results from excessive formation of vapor in the fuel system, vapor-locking tendency has been defined in terms of the relationship between temperature and the ratio of vapor to liquid.[1-3] For controlling gasoline manufacture, it is more convenient to relate vapor lock to Reid vapor pressure and some point on the ASTM distillation curve.

The vapor-locking characteristics of all cars were affected by wind velocity; higher velocities resulted in greater vapor-pressure tolerance at a given air temperature. To correct all data to the common basis of a 5-mph wind, wind-velocity effects were computed in terms of Reid vapor pressure and air temperature at incipient vapor lock. The correction for each make of car is different, and must be experimentally determined. Examples are shown in Figure 5.

If volatility limits are to be set which will prevent vapor lock, the vapor-locking tendency of the most critical cars must be the basis. Of the cars tested, car "B" was most critical from 50 to 70 F., and car "D" from 70 to 110 F.; a composite correlation for the complete test range of 50 to 110 F. is shown in Figure 6.

Carburetor icing, difficulty in starting hot engines, and over-choking are problems which are also related to volatility. Carburetor icing cannot be eliminated by any feasible changes in motor-fuel volatility, but it can be helped by changes in carburetor design or by the addition of additives to the fuel.[5-9] Engines generally take longer to start at, or above, running temperatures than when cold. In some cars the time was not affected by fuel volatility; in others, increased volatility resulted in longer starting times which roughly correlated with the 158 point. Few experimental data have been obtained on over-choking. These problems could bear further study, perhaps by some such group as the Coordinating Research Council, Inc.

Applications

A winter gasoline with good volatility for use in Florida would be poor on starting and warmup in Minnesota. Volatility limits are set up so that each area will have a motor fuel of good volatility for the prevailing climate. Results of this investigation have been used to assist in establishing seasonal volatility limits for gasoline and to compare the starting, warmup, and vapor-locking performance of motor fuels.

When volatility limits are set for spring, fall, and winter, starting and warmup are prime factors; but vapor lock must also be considered. Lower limits assure satisfactory starting and warmup at the lowest air temperatures expected, and upper limits protect against vapor lock at the highest temperatures.

Preventing vapor lock is the main volatility problem in the summer. Limits of vapor pressure and 158 point must be compatible with probable maximum temperatures. Figure 6 shows the relationship between Reid vapor pressure, 158 point, and air temperature at incipient vapor lock. In setting volatility limits at the refinery, 5 F. can be added to the temperature for incipient vapor lock because of the loss of light ends during shipment and storage.

Conclusion

The mechanism of warmup, and how it relates to fuel volatility and engine design, represent a field for additional research. Differences in vapor-locking characteristics between cars probably result from differences in body design and in the location of fuel pumps and lines relative to points of high temperature. The marked influence of wind velocity on vapor lock emphasizes these effects. Attention to such details as the location of fuel-system components and proper shielding from high-temperature sources can improve the ability of a car to use high-volatility fuels without vapor lock. At least one refiner has predicted that motor fuels will become more volatile in the future.[3] The economic pressure to conserve light hydrocarbons by incorporating more of them in gasoline is strong. The car manufacturer can help conserve petroleum—and reduce incidence of trouble—by using practical methods for preventing vapor lock and associated difficulties.

ACKNOWLEDGMENT

The authors express their appreciation to Mr. Gilbert Way and Ethyl Corporation for use of laboratory facilities at San Bernardino, Calif.

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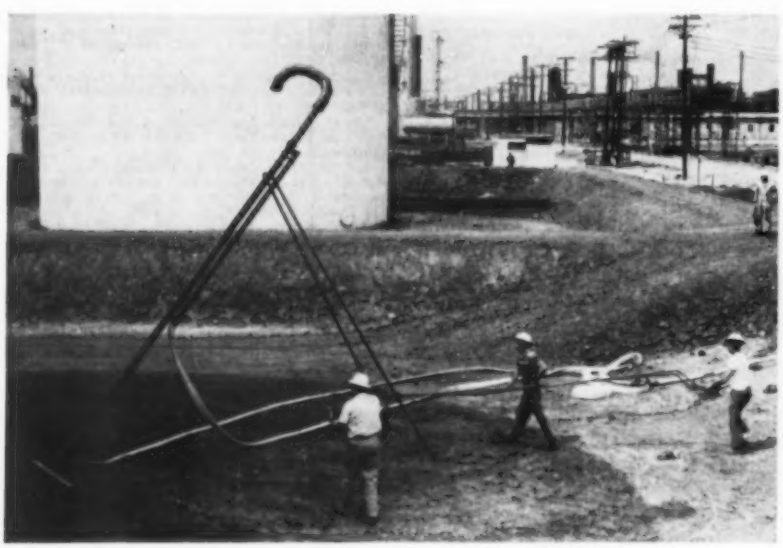
Hydraulic Foam Tower Saves Manpower, Time

1. An hydraulic foam tower that can be put in operation with a third of the manpower and time required by the old system has been installed at Shell Oil Company's Houston Refinery. Formerly it took 12 men to put the tower in position. Now four can do it.

2. The crew need no longer stop for 10 to 15 minutes to assemble a many-pieced tower. They connect the hoses and the tower is ready for operation within 3 or 4 minutes.



3. The poles are extended to raise the tower into horizontal position. Then hydraulic power takes over.

4. L. J. Grossheim, manager of the Fire and Safety department, sees the tower in final position. Grossheim was largely instrumental in developing the hydraulic feature of the tower.

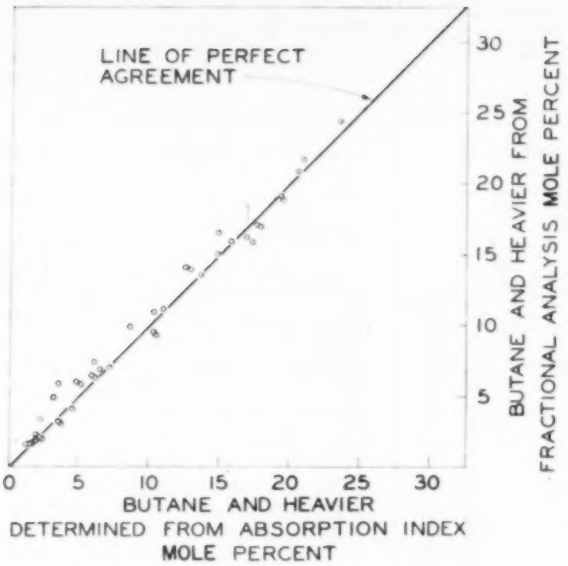


Figure 1. Good agreement is shown by this plot of butane and heavier determined from absorption index vs. from fractional analysis.

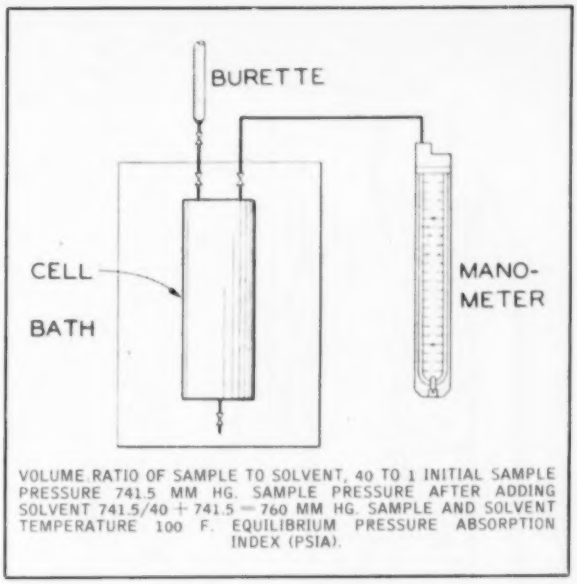

BURETTE
CELL
BATH
MANO-
METER
VOLUME RATIO OF SAMPLE TO SOLVENT, 40 TO 1 INITIAL SAMPLE PRESSURE 741.5 MM HG. SAMPLE PRESSURE AFTER ADDING SOLVENT 741.5/40 + 741.5 = 760 MM HG. SAMPLE AND SOLVENT TEMPERATURE 100 F. EQUILIBRIUM PRESSURE ABSORPTION INDEX (PSIA).

Figure 2. Absorption index apparatus.

A new test for natural gas—

Absorption Index

This test offers a simple and rapid method for estimating the amount of butane and heavier content of a natural gas with a precision of plus or minus 5 percent based on fractional analysis.

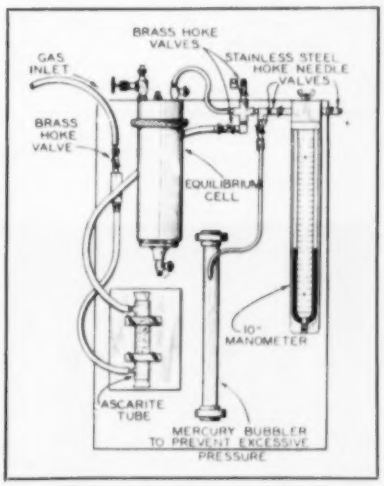


Figure 3. Sampling assembly.

T. W. Legatski, J. W. Tooke and L. A. Grundy,
Phillips Petroleum Company, Bartlesville, Okla.

FREQUENTLY IT BECOMES necessary in engineering studies of natural gas processing methods to have available information on the "butanes and heavier" or "propane and heavier" contents of the natural gases under consideration. Most of the analytical methods currently employed for the development of such information are costly, time-consuming, and are subject to the ofttime serious limitation that the work must be done in a well equipped central laboratory. In some instances where analytical information is needed it is quite possible that some sacrifice in absolute accuracy could be tolerated in the interests of speed, cost and convenience.

Objective. It was in an attempt to overcome the several objectionable features of the usual analytical methods that the following work was undertaken, the objective being to develop a simple test method, the results of which would correlate reasonably well with composition.

Since the primary concern was with the heavy fractions of natural gas, a potentially satisfactory test method would have to be affected primarily by variations in the content of the higher molecular weight compounds. As a promising lead, it was reasoned that if a measured quantity of a reproducible pure hydrocarbon solvent could be brought into contact with a measured quantity of the sample gas confined in a chamber under standard conditions, the resultant final pressure on the system could be related to the concentration of the readily condensi-

Original presentation as "Absorption Index—A Simple Test for an Important Property of Natural Gas" at the 32nd Annual Convention of NGAA, Houston, April 30, 1953.

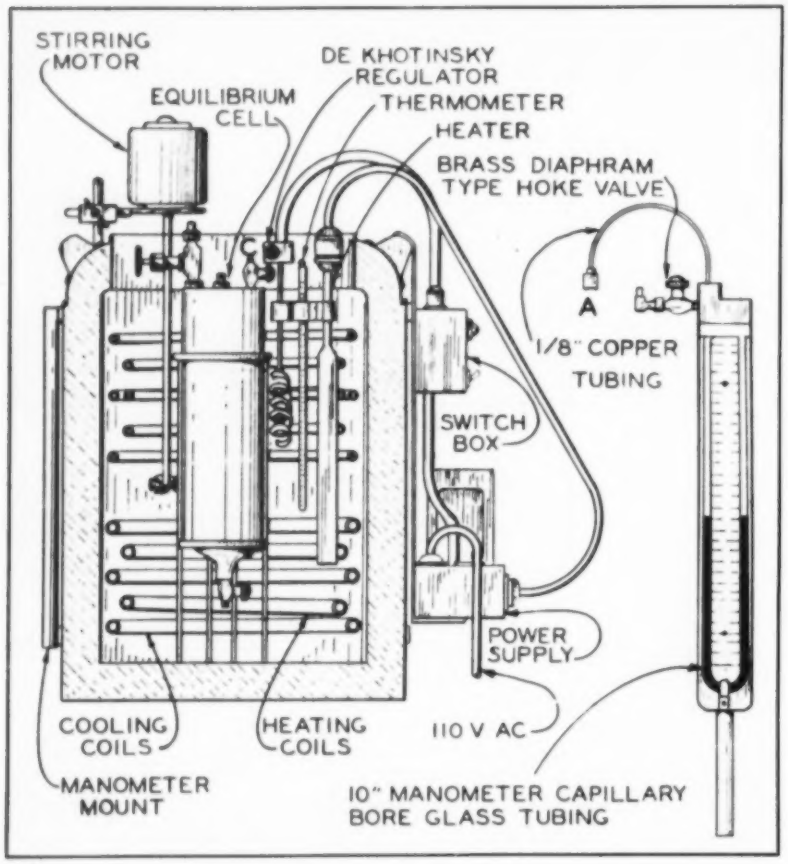


Figure 4. Constant temperature bath.

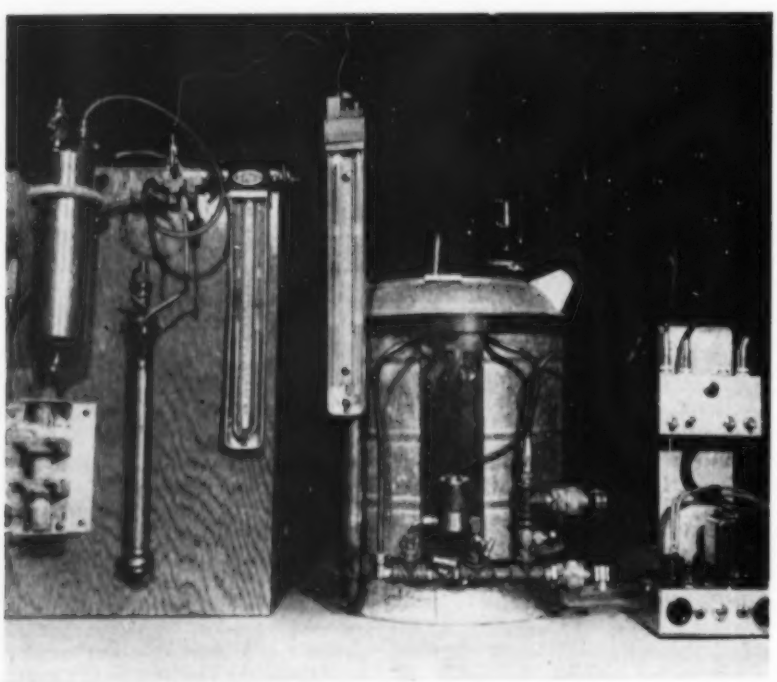


Figure 5. Absorption index apparatus.

ble hydrocarbon fractions present in the gas. The probability of such a relationship existing is found in the consistency with which the over-all composition varies as the content of any one particular hydrocarbon varies.

Following this lead, and as a result of a series of preliminary calculations using various pure hydrocarbon solvents and a wide range of hypothetical gas compositions, it was concluded that a promising solvent was normal octane, and that a promising ratio of gas to solvent was 40 to 1 for a contacting temperature of 100 F. and an initial gas pressure at 100 F. of 760 mm. For these conditions the final pressure on the system would range from about 12 pounds absolute to about atmospheric depending upon the composition of the gas under test. The approximately three-pound difference in final pressure would roughly correspond to a change of 20 mole percent in the "butanes and heavier" content.

The test has been designated as the adsorption index test and the test result is referred to as absorption index. By definition, the adsorption index is the equilibrium pressure in psia obtained when 40 volumes of sample gas and one volume of liquid normal octane are contacted under the prescribed initial conditions of 760 mm Hg pressure and at a temperature of 100 F.

Apparatus. The first apparatus was constructed to prove up the idea in a series of tests on gases of various compositions. The details of construction of the apparatus are unimportant as long as the essential features are present. The apparatus used in this work is not necessarily the best arrangement and for that reason will not be discussed in detail. The essential features, however, were incorporated and are illustrated in Figure 2. The equilibrium cell is shown with three openings. One opening is connected to a burette for addition of solvent, another to a manometer for measuring pressure and still another, on the bottom of the cell, was used for draining the solvent and cleaning the cell. The cell had a total volume of 967 ml. In order to achieve the required ratio of sample to solvent the cell was initially filled with sample to a pressure of 741.5 mm Hg. The volume of normal octane added to the system from the burette was 23.6 ml. The vapor space then above the normal octane was 967 minus 23.6 or 943.4 ml which gave a gas to solvent ratio of 40 to 1. The decrease in gas volume in the cell caused by the addition of the normal octane increased the pressure to 760 mm Hg neglecting solution and vapor pressure effects. The

cell was contained in a water bath which was maintained at 100 F. The ten-inch mercury manometer permitted measuring the pressure in the cell.

A drawing of the apparatus used for sampling the natural gas is shown in Figure 3. The equilibrium cell is in the upper left hand corner. The gas sample was admitted through the line on the left. It passed through the ascarite tube then to a four-way block. The mercury bubbler prevented excess pressure in the system and the manometer indicated the pressure. From the four-way block the gas was taken to the equilibrium cell. In Figure 4 the equilibrium cell is shown in position in the constant temperature bath. The bath was fitted with cooling coils, heating coils for circulating hot water and with electrical heaters for supplying heat. Once the bath was heated to approximately 100 F. by circulating hot water, this was discontinued by action of a solenoid valve and the heaters took over and were controlled by a DeKhotinsky thermoregulator. On occasion it was necessary to cool the bath slightly by drawing air through an iced coil and into the cooling coils. The stirrer maintained a uniform temperature throughout the bath. In this way it was possible to maintain temperatures within the bath at 100 F. $\pm$ 0.1 F. as indicated on an ASTM Reid vapor pressure thermometer. The ten-inch mercury manometer shown at the right was used to obtain the equilibrium pressure in the cell by connecting the small line to one of the valves on the cell. Pressures in the cell could be measured to $\pm$0.02 psi.

Other equipment which was used but is not shown in this figure was a 50 ml burette for measuring the normal octane into the equilibrium cell, an aneroid barometer and a supply of normal octane and normal hexane. The hexane was used to wash the cell and prepare it for the next test. The photograph in Figure 5 shows how the equipment looked when assembled.

Procedure. In preparing for a test, the cell, after having been rinsed with hexane to remove residual materials from prior tests, was connected to a sample train. The sample train consisted of a pressure reducing regulator, a cotton waste filter, and an ascarite tube in that order. The ascarite tube served to remove carbon dioxide, hydrogen sulfide and water vapor from the gas being sampled. The manometer attached to one of the cell openings served to indicate pressures during the sampling operation. The flow of gas through the cell was permitted to continue long enough to purge the system.

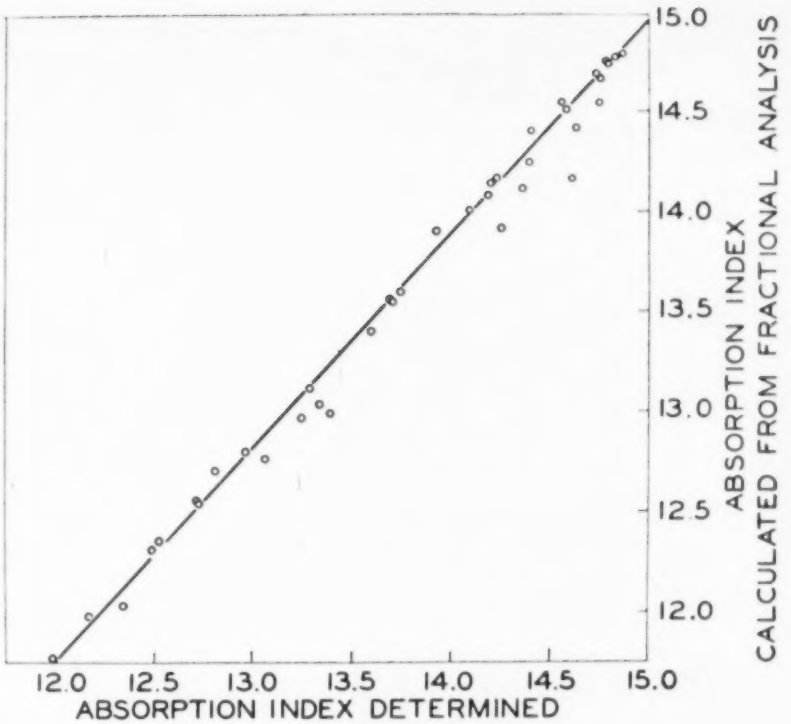


Figure 6. Comparison of absorption index determined vs. calculated from fractional analysis.

This usually required about 15 minutes. At the end of this time a sample of gas was trapped in the equilibrium cell and the cell was placed in the constant temperature bath which had previously been brought to 100 F. The cell was still connected and open to the manometer.

The cell was allowed to remain in the bath for 15 minutes to bring its temperature to 100 F. Without removing it from the bath the pressure within the cell was then adjusted to 741.5 mm Hg absolute by bleeding off a sample. After this pressure adjustment all valves were closed on the cell and it was removed from the bath. Exactly 23.6 ml of normal octane was then added to the cell from a burette. The addition of this volume of material to the cell had the effect of creating an initial cell pressure of 760 mm Hg in the absence of any solution and vapor pressure effects. The cell was vigorously shaken and returned to the bath. Shaking was repeated at five-minute intervals until the cell had been in the bath for 30 minutes. The mercury manometer was then attached to the cell, the mercury was leveled, the valve on top of the cell was opened to the manometer, and the final pressure was read from the manometer.

Very lean gases cause the final reading on the manometer to be about one atmosphere or slightly more than one atmosphere. Richer gases give final readings of less than one atmosphere. The absorption index was obtained by adding to or subtracting from the barometric pressure the manometer reading and expressing this resultant value in terms of psia.

Discussion. The absorption index was run on 34 samples. Each time an adsorption index was determined a sample of the same gas was later analyzed by low temperature fractional analysis. These samples represented a wide variety of gases. They were taken in Reserve Field of Osage County, Oklahoma, the Texas Panhandle Field around Pampa, the Permian Basin around Odessa, Texas, and in the Chocolate Bayou Field in Brazoria County, Texas. The "pentanes and heavier" contents ranged from about 0.3 mole percent to almost 12.0 mole percent. The nitrogen contents varied from less than one percent to nearly 25 percent. Some of the samples were taken from oil wells, some from gas wells and still others from gas-condensate wells. The samples from Oklahoma, the Panhandle and Chocolate Bayou were mostly sweet while those from the Permian Basin were generally very sour. A deliberate effort was made to obtain extremes in hydrocarbon composition and in nitrogen content.

It is evident, from the definition,

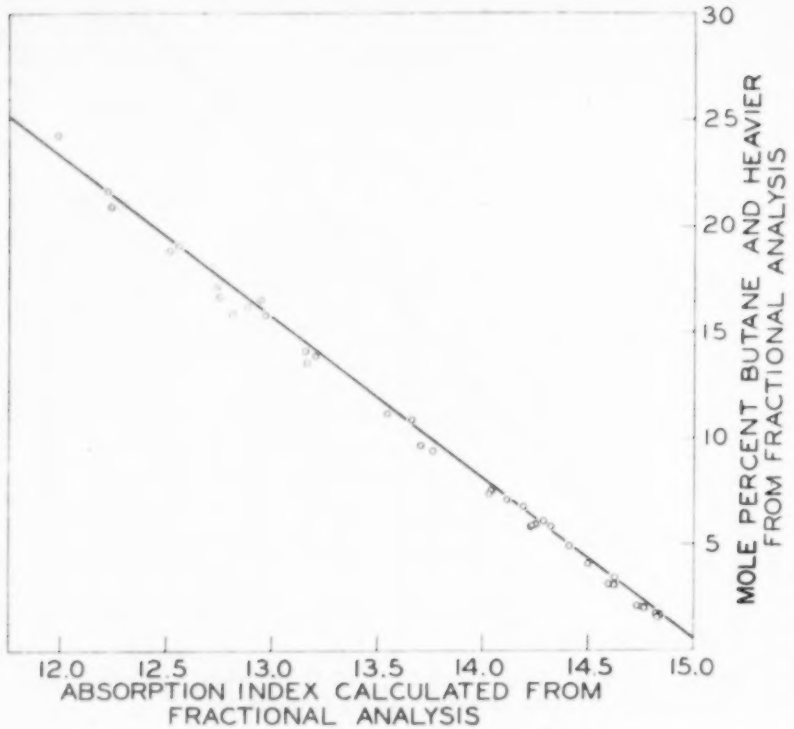


Figure 7. Calculated absorption index vs. butane and heavier from fractional analysis.

that it is possible to calculate absorption index if the composition of the gas sample is known. This was done for each sample using the analysis as obtained from low temperature fractional analysis and idealized K constants taken from the Engineering Data Book of the Natural Gasoline Supply Men's Association. The calculated absorption indices are plotted against the observed absorption indices for the 34 samples in Figure 6. If the calculated absorption indices had agreed perfectly with the observed data then all points would have fallen on a 45° line. This did not occur although they do agree rather closely. The fact that these calculated and observed values do agree closely indicates that the absorption index test is a valid test and measures what it was intended to measure. The numerical values obtained for the observed absorption indices are higher than the calculated absorption indices by a more or less constant amount. This indicates that the K constants used in the calculations are not exactly applicable to these systems. Had the correct K constants been available then the two sets of data would probably have been in better agreement. Since the two sets of data disagree more or less by a constant amount, it is then in order to adjust the calculated values upward by the indicated amount. The scattering of points above and below the average line is an indication of the reproducibility of the absorption index test neglecting any errors that may occur in the fractional analysis.

As previously stated the absorption index test was designed to indicate the amount of high molecular weight hydrocarbons in natural gas. How well this is accomplished is shown in Figure 7, where the adjusted calculated absorption index is plotted against the amount of butane and heavier in mole percent found by fractional analysis. This correlation appears to be quite satisfactory. The average line produced by this plot may be used to predict the butane and heavier content of natural gas from absorption index.

In Figure 1, butane and heavier in mole percent, as determined from observed absorption index and the correlation shown in Figure 7, are plotted against butane and heavier in mole percent as found by fractional analysis. With few exceptions all samples fall within ±5.0 percent of perfect agreement. This figure is really the test of the method. It shows that absorption index of a gas can be measured, and, with the aid of the correlation shown in Figure 7, the butane and heavier content of the gas can be estimated in mole percent with a precision of plus or minus 5 percent as compared to fractional analysis.

TABLE 1

Effect of Nitrogen on Absorption Index

	Nitrogen Content, Mol. Percent	CALCULATED ABSORPTION INDEX	
		Containing Nitrogen	Nitrogen Free
Sample 7	11.3	14.74	14.69
Sample 10	24.8	14.83	14.63

Limitations. As with all methods of test certain limitations are inescapable. Most natural gases contain some non-hydrocarbon components. The most common of these are carbon dioxide, hydrogen sulfide and nitrogen. The content of these non-hydrocarbons may vary from less than 1 percent to 25 percent or more. Carbon dioxide and hydrogen sulfide are of little consequence as far as the determination of absorption index is concerned. These are removed before the sample is taken for test by an ascarite tube as shown earlier. Nitrogen cannot be removed and is therefore taken with the test sample into the absorption index apparatus. The effect of nitrogen on the absorption index is to increase the observed numerical value over what it would have been had no nitrogen been present. This effect however is small and for practical purposes may be ignored. Even large concentrations of nitrogen have only a small effect on absorption index. The magnitude of this effect is shown in Table 1 where the calculated absorption index for two samples with and without nitrogen is illustrated. Sample 7 contained 11.3 mole percent nitrogen. Its calculated absorption index with the nitrogen was 14.74. Without the nitrogen its calculated absorption index was 14.69. Similarly sample 10 contained 24.8 mole percent nitrogen. Its calculated absorption index was 14.83 with the nitrogen and 14.63 without the nitrogen.

As with other tests dependent upon physical measurements, the absorption index test requires that temperature, volume and pressure be measured with precision. This imposes no undue requirement as it is here demonstrated that good reproducibility may be attained with simple equipment. There is evidence however that better results are possible with refinements in technique and apparatus.

In conclusion, the absorption index test offers a simple and rapid method for estimating the amount of butane and heavier content of a natural gas with a precision of plus or minus 5 percent based on fractional analysis.

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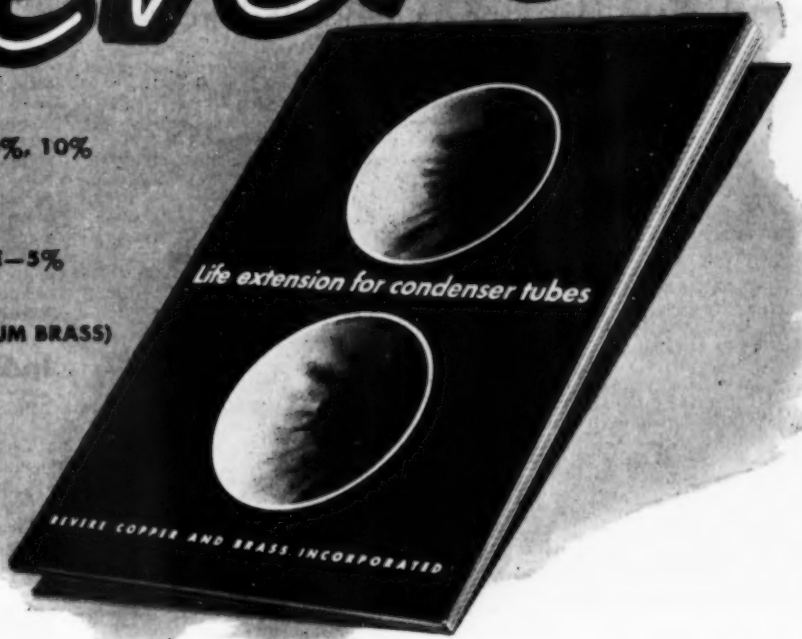

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John P. Street

Fred Z. Zenz

E. F. Gibbons

Hedrick Trio Has Process Work Background

Henry E. Haley, D. N. McClanahan and John P. Street, "A Critical Study of—The Selling Price of Synthetic Rubber Plants," page 113.

This writing team is connected with Wyatt C. Hedrick Engineering Corporation, where each has something to do with process work.

Haley, who joined the organization in 1950, has been concerned with process design and economic evaluation of refinery and petrochemical plants. Before going with Wyatt C. Hedrick, he was with McCarthy Chemical Company, where he worked with operation of oxygen and petrochemical plants, and later with O. L. Olsen Company, where his assignment was gasoline plant process design. A former naval officer specializing in the Japanese language, he received a B.S. degree in chemical engineering in 1949 and a M.S. degree in the same subject in 1948, both from the University of Texas.

McClanahan, who has a B.S. degree in chemical engineering from Georgia School of Technology and a M.S. degree in same subject from Massachusetts Institute of Technology, is in charge of process work at Wyatt C. Hedrick. With the corporation since September, 1949, he has been principally concerned with petroleum refining, butylene and butadiene production and other phases of synthetic rubber manufacture. His previous experience includes four years with Standard Oil Company (New Jersey) at Baton Rouge, La., (now Esso Standard Oil Company), and three years with Fomac Engineers in Houston. At Standard his work was in connection with butyl rubber manufacture and catalytic cracking. At Fomac he worked in design and economic studies for oxygenated and other petrochemical processes.

Street, a former naval officer in the Gunnery department of a submarine and cruiser, joined Wyatt C. Hedrick in August, 1949. His work has consisted of refinery mechanical and process design, chemical plant process design, and economic evaluation of synthetic rubber and other chemical plants. He obtained his B.S. degree in general engineering from the United States Naval Academy in 1943, his B.S. degree in petroleum engineering from Louisiana State University in 1948. Prior to joining the Hedrick organization he worked with gasoline plant process design at Hudson Engineering Corporation.

Zenz Follows Trend With Third Appearance

Fred Zenz, "Visualizing Gas-Solid Dynamics in Catalytic Processes," page 123.

With this his third appearance in Petroleum Refiner, Fred Zenz is following what has become a growing trend among our authors. And that is that they are almost certain to write for us again and again!

Back in 1950, Zenz turned out "Screen Skirted Bubble Caps," which was followed only last January by "Froth and Foam—The Bases for Tower Sizing."

For the last seven years Zenz has been associated with Hydrocarbon Research, Inc., engaged in process development and process engineering. Concurrent with his duties at Hydrocarbon, he was, from 1950 to 1951, special lecturer at New York University, department of chemical engineering, and, since 1952, has been part-time consultant to a chemical process equipment company. Prior to joining Hydrocarbon he was associated successively with The M. W. Kellogg Company, Kellex Corporation and Carbide & Carbon Chemicals Corporation. While with the last two companies, he was also a member of the Special Engineer Detachment of the army service forces' Manhattan Project.

Gibbons Authors Book On Canadian Chemicals

Eugene F. Gibbons, "Where is Canada Going in Petrochemicals," page 89.

As head of the public relations program at Designers for Industry, Inc., Cleveland, Eugene Gibbons directs the company's technical writing program. He has recently authored a book on the Canadian chemical industry to be published later this year by R. S. Aries & Associates.

A one-time editorial writer for *Petroleum Processing* magazine, he was before that a research assistant for five years in the Organic Research department of Lubrizol Corporation, manufacturers of additives. He studied basic engineering at Indiana University and New York University while a member of the Army Specialized Training Program during World War II. After the war he saw service with U. S. Army Engineers in Italy. Following his discharge from the service, he returned to obtain his B.A. degree from Western Reserve University.

Indiana Standard Trio Sets Volatility Effect

Charles J. Domke, Charles B. Tracy and Harold R. Taliaferro, "Volatility Sets Automobile Performance," page 151.

Charles Domke is an automotive engineer in the research department of Standard Oil Company (Indiana), con-

Domke

Taliaferro

Tracy

Stark

DU PONT

PETROLEUM CHEMICALS DIVISION NEWS

DU PONT

July ★ *One of a Series of Interest to the Petroleum Industry* ★ *1953*

Next Du Pont Gasoline Survey To Be Mailed On July 24

Results of the latest Du Pont Quarterly Motor Gasoline Survey will be mailed to refiners on Friday, July 24.

These surveys furnish current data on octane numbers and TEL content of motor fuels marketed throughout the United States.

Refiners have found the Du Pont Gasoline Survey to be valuable for indicating trends and competitive standings. And there are many who also use it as an aid to their marketing programs.

When the customer says

It's RARELY the fault of the gasoline!

The above headline and cartoon have been reproduced directly from a folder recently put out by Du Pont. Its purpose is to prompt your dealers on how to cope with a common—but often hard-to-answer—customer complaint.

"How many miles to the gallon?" is a familiar measure of both engine and fuel performance. Yet, ever since the gasoline engine first came into popular use, this method of measurement has been frequently misunderstood and misinterpreted. As a result, the gasoline dealer and the oil company he represents are often maligned.

In most cases where a customer complains to a gasoline dealer about poor mileage, improper car maintenance or erratic driving habits rather than gasoline quality are to blame. But service station men are sometimes hard put to explain this to the customer's satisfaction.

The new Du Pont folder makes it easier for your dealers to answer the complaint by serving as a constant reminder of all the mechanical and human factors that contribute to poor gasoline mileage . . . such as dirty spark plugs, a plugged muffler, or accelerator pumping. It quickly pinpoints these factors in concise, easy-to-understand language. There are no long, involved explanations. Simple line cartoons make many of the points graphically clear.

This new folder, "*When the customer says 'poor mileage,'*" is an appropriate sequel to a previous Du Pont folder, "*When the customer says 'knock.'*" The "knock" folder has been extremely popular among oil companies and dealers who have, to date, requested more than 200,000 copies of it.

For sample copies and information on how to obtain the "poor mileage" folders for your dealers, write to any of the Du Pont Petroleum Chemicals Division district offices.

Du Pont Engineering Services Help Refiners Achieve More Efficient Blending Plant Design and Operation

The use and safe handling of tetraethyl lead are highly specialized operations which frequently give rise to some rather knotty refinery problems.

To help refiners solve these problems economically and efficiently, the Du Pont Petroleum Chemicals Division offers special engineering services in blending plant design, construction and operation. This assistance covers every phase of the subject from site selection to training of blending plant personnel.

TO HELP YOU set up efficient TEL blending plant operations, Du Pont will supply you with complete construction drawings and detailed specifications.

After years of study and experience, Du Pont engineers have been able to set up standardized recommendations for plant design and operating procedures. Large refineries generally find these useful supplements to the work of their own engineering departments.

To the small refinery, these recommendations are often extremely valuable as a basis for setting up the entire blending operation.

Since the plant designs are drawn to standard specifications, they may not always solve a particular problem. Therefore, Du Pont is prepared to offer advisory help in tailoring standard designs to fit individual circumstances.

SELECTING THE SITE

Railroad, pipeline and storage facilities, as well as the relative position of refinery units, all have a bearing on the location you choose for a blending

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OVER

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plant. Soil conditions, local code requirements and availability of materials must also be considered. Based on a wide variety of experience in dealing with these factors, the Du Pont engineering service men are prepared to help pick a blending plant site most advantageous to you.

PLANT DESIGN

Complete construction plans for TEL blending plants are available to all refiners. When necessary, Du Pont engineers will be glad to discuss special designs to meet unusual requirements. For example, Du Pont recently helped a large user design a special piling arrangement to support a blending plant on swampy land.

Today, many of the larger refineries are setting up facilities for continuous component blending of refinery stocks, tetraethyl lead, dyes, antioxidants and other additives. If you are considering such a plant, our engineering service men can assist your own engineers on the design.

Even after the actual construction has started, a Du Pont representative is available for consultation. And he will be glad to visit the job to discuss progress with your contractor whenever needed.

PERSONNEL TRAINING

To insure the health and safety of blending plant personnel, a specialized training program is required. Du Pont representatives are prepared to provide complete, detailed recommendations for safe and efficient operation of the blending unit and to assist with the actual training of operators. Also, a member of the Du Pont medical staff will explain the health hazards involved and outline the precautions which should be observed.

DU PONT REPRESENTATIVE (right) demonstrating proper use of tank cleaning safety equipment to refinery personnel.

EASTERN DISTRICT MANAGER

ALFRED R. MULLIS is manager of the Du Pont Petroleum Chemicals Division Eastern District. His first association with the petroleum industry began in the Smackover Oil Fields at the age of 10. His first refinery experience was at a large Gulf Coast refinery during the summer months, while attending college.

In 1938 he graduated from Rice Institute, and received a B.S. degree in chemical engineering. Following graduation, he was employed in the Research and Development Department of the Humble Oil and Refining Company.

During World War II, Mr. Mullis spent four years in the Navy and was attached to the Bureau of Ships as a Petroleum Inspector. In 1946 he resumed his association with the Humble Oil Company in the Petroleum Inspection Department.

Mr. Mullis joined the Du Pont Company in 1947 as a sales-service representative for the Petroleum Chemicals Division. He was assigned to the Gulf Coast District and became manager of this district in 1950. In 1952 he was transferred to New York City to his present position as eastern district manager.

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Meet Our **Authors . . .**

James A. Hunter

H. W. Luetkemeyer

H. A. Cataldi

R. J. Askevold

A. E. Harnsberger

cerned with the testing and development of motor fuels. Before joining Standard in 1941 he was associated with Burgess Battery Company. A member of the Society of Automotive Engineers, he was graduated by Loyola University, Chicago, with a B.S. degree in chemistry.

Charles Tracy was graduated by Ohio State University, Columbus, Ohio, with a bachelor's degree in mechanical engineering. He joined Standard in 1947 and is now an automotive engineer in the research department. He has previously worked on various phases of motor-fuel testing and development, with particular emphasis on combustion-chamber deposits and volatility.

Prior to his present assignment as a section leader in Standard's research department, Harold Taliaferro was concerned with the finishing and blending of motor gasolines, aviation gasolines and distillate fuels. Before joining Standard he was with Lever Brothers Company.

Stark Gets Assist from Siegelman and McDonald

David J. Stark, "Tuscola Plant Located Closer to Petrochemical Markets," page 139, PETROLEUM REFINER, June, 1953.

David J. Stark, whose biography was unavoidably omitted last month, wrote his paper on deep extraction at Tuscola with the assistance of G. A. Siegelman, process superintendent, and J. F. McDonald, area superintendent of Hydrocarbon Recovery, both of National Petro-Chemicals Corporation. Stark is plant manager at National Petro-Chemicals.

Born in Calgary, Alberta, Canada, Stark attended the University of Oklahoma, college of chemical engineering. He graduated in 1943, a member of Tau Beta Pi and Sigma Tau. That year he joined a large petroleum refining organization in Montreal, Canada, as a technologist, serving subsequently as Alkylation department manager, chief technologist, project engineer and Catalytic Cracking department manager. He joined National Petro-Chemicals Corporation in 1951 as process superintendent. He recently advanced to his present post.

As process superintendent he supervised the design and construction of National Petro-Chemicals' large hydrocarbon and petrochemical plant in Tulsola, Ill.

Pure Pair Teams With **Corrosion Researcher**

H. A. Cataldi, R. J. Askevold and A. E. Harnsberger, "Estimating the Corrosivity of Crude Oil," page 145.

As assistant project engineer in the Engineering Research department of Standard Oil Company (Indiana), Horace Cataldi devotes all of his time to corrosion research. He received his B.S. degree in chemical engineering from the College of the City of New York in 1940, his Ph.D. degree in chemical engineering from the University of Illinois. For a time he was employed by the Navy Department as a physicist. Also, before joining Standard in 1950, he worked as a physical chemist and assistant department supervisor in electronics at Oak Ridge.

Askevold, a Chicagoan, joined the staff of The Pure Oil Company's Research and Development Laboratories as a research chemist following his graduation in 1934 from the University of Chicago, where he was elected to Phi Beta Kappa. For the past eight years he has been the director of the analytical research and service division of the laboratories.

Following his graduation from Virginia Polytechnic Institute, where he majored in mechanical engineering, Harnsberger worked for four years in the Centrifugal Pump department of Worthington Corporation as a test engineer, designer and field engineer. He has been with Pure Oil since 1924, when he became assistant to the Refinery chief mechanical engineer. In 1928 he became chief mechanical engineer, and in 1942 he was appointed chairman of the refinery control board. Since 1949 he has been manager of the refinery division of the company.

Former Marine Holds Apprentice Home Course

James A. Hunter, Jr., "Solve for Vessel Thickness Graphically," page 112.

This former marine was born in Houston, graduated from Texas A & M College and is a member of Tau Beta Pi. After graduation he worked for a short time at Douglas Aircraft Company in El Segundo, Calif. In October 1950 he joined the Works Engineering department, Carbide and Carbon Chemicals Company, as a piping draftsman. After almost a year Hunter was advanced to his present position as project engineer in the mechanical engineering group. At Carbide he teaches a blueprint reading and sketching course for the company's apprentice program. At home he instructs two small apprentices of his own —John, two and a half, and Matthew, four months.

Reynolds Enjoys Work With Technical Subjects

Sanford C. Reynolds, "Entrainment Eliminators Save Money," page 138.

A liking for technical subjects and analyzing their merits and applications has led Sanford Reynolds to write specifications, handbooks and similar works in such fields as metals, chemicals, and building products. And, in his own words, he writes about them "in a language that is strictly nontechnical."

Reynolds, now with Metal Textile Corporation, was graduated from Princeton University in 1916, shortly after which he served two years with the French Army in World War I. Married, he has three children "all over 21." His hobbies include "getting away to the woods, water or mountains where nobody can find me, gardening and trying to grow old as gracefully as a very modest income will permit."

Luetkemeyer Has Research Background

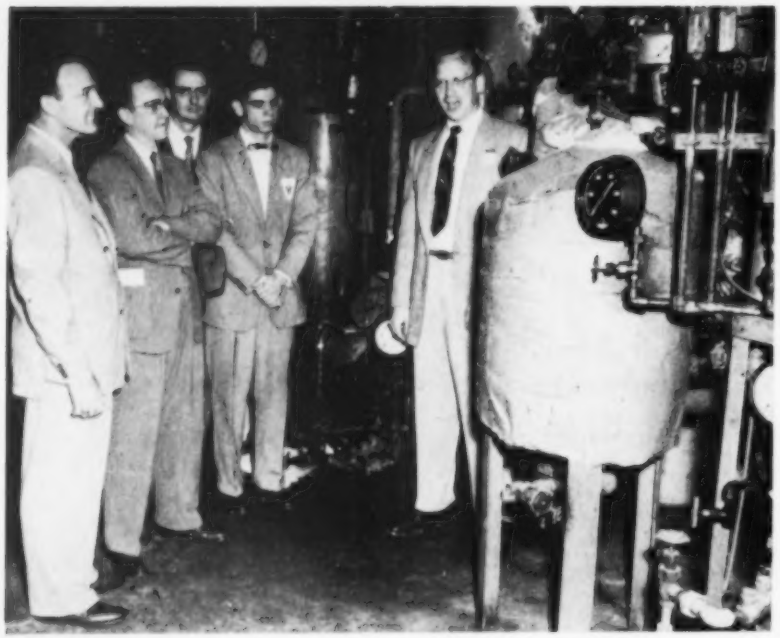
Henry W. Luetkemeyer, "Bearing Failures—Diagnosis and Prevention," page 135.

Henry Luetkemeyer was born in Cleveland. He attended the Chicago School of Aeronautics and the University of Michigan, where he received a B.S. degree in mechanical engineering.

Following stints as a machinist's apprentice, manufacturer's representative, salesman, railroad civil engineer and traffic engineer, he joined The Cleveland Graphite Bronze Company. This was in 1933. In his twenty years with Cleveland, his work has been mainly in the development and research field, and in that time he has served as chief experimental engineer, assistant chief engineer, chief engineer and vice president—engineering and research.

When his company became the Clevite Corporation in January, 1953, Luetkemeyer became vice president of Clevite-Brush Development Company, a division of Clevite Corporation.

What's **Happening** in the Industry...



With Your Editors—

John McKetta, Bob Phillips, Bob Spann and George Gibbs of the Refiner staff listen to L. J. Parrigin's explanation of the catalytic cracking pilot unit in Standard Oil Development's laboratories at Linden, N. J.

Warren Petroleum's LaFortune Sworn in as New PAD Deputy

J. A. LaFortune of Warren Petroleum Corporation took his oath of office last month as new deputy PAD, replacing J. Ed Warren. With formal clearance from Interior Secretary McKay, which followed a recommendation from J. Ed Warren and the approval of the National Petroleum Council's Personnel Committee, the oath was administered in the presence of McKay. Looking on were members of PAD's Gas Industry's Advisory Council.

LaFortune will serve without compensation. Warren held the post on a government salary since he was an independent producer and did not continue on any company payroll.

LaFortune pledged his hope to follow in the footsteps of Warren. He revealed that he previously had rejected the offer from Commerce Secretary Weeks.

7 Percent Rise in TEL Use In 1953 Forecast by Du Pont

E. I. du Pont de Nemours & Company has forecast a 7 percent increase this year over 1952 in tetraethyl lead used to increase the octane number of gasoline. The company noted that the "cost of design, installation and operation of new equipment to produce the last few octane numbers holds the answer to TEL usage, and to date, this has been in favor of TEL." Du Pont says the supply of TEL for gasoline can meet any demand.

Sohio Cleveland Refinery Gets Safest Refinery Award of NPA

The National Petroleum Association, department of Fire and Accident Prevention, has awarded the Safest Refinery award to the Cleveland No. 1 refinery of The Standard Oil Company (Ohio). The award was made at the NPA department's twenty-eighth convention.

The award certificate, in recognition of Sohio's No. 1 refinery operating throughout 1952 without a lost-time accident, was presented to William F. Smith, safety engineer of the Cleveland refinery. The Sohio refinery safety record, including all of 1952, was extended for 740 days or 3.1 million man-hours without a lost-time accident.

Grace Chemical Board Elects Charles E. Wilson Chairman

Charles E. Wilson has been elected chairman of the board of directors of Grace Chemical Company. Wilson formerly was president of the General Electric Company, first chairman of the Defense Mobilization Board, and executive vice chairman of the War Production Board. He also is chairman of the executive committee of the board of directors of W. R. Grace & Company.

Grace Chemical Company, formed a year ago, now has under construction its first manufacturing unit, a $19 million nitrogen plant located near Memphis. The plant is expected to be on stream in about a year.

Wilson was with General Electric for 51 years.

ACE Chairman Says Atom Power Will Not Supplant Petroleum

Atomic Energy will only supplement petroleum as fuel and "is not going to replace gasoline" as a propulsive force for motor vehicles, Chairman Dean of the Atomic Energy Commission predicted recently. He said that a newly perfected "breeding" process has brought atomic energy closer to the point where it would compete with existing types of fuel.

"I believe that atomic energy will fill an incremental, not displacement, role for petroleum," he said. "We are not going to have atomic cubes in cars. Atomic energy does not fit that field at all."

In addition, he noted, the U. S., despite its tremendous natural resources, "has never had a surfeit of power or energy" to meet its growing industrial demands. "Demand always seems to stay ahead of our supply of energy," he said.

Sale Instead of Lease Being Considered for Missouri Plant

The Army, at the behest of Senator Symington (D., Mo.), is considering selling the Louisiana, Mo., synthetic fuels facilities instead of leasing them. Both Senate and House Armed Services Committees are marking time on reviewing the Army's leasing plan until they receive word on the new development.

Symington's office confirmed that the Senator has made the request to Army Secretary Stevens. It was understood that the point at issue is the requirement that the Army incorporate a "capture" clause in the lease, whereas in the sale of facilities the contract could provide merely that production would go to the Armed Services if needed.

Should sale, rather than lease, procedure be adopted, the General Services Administration will handle the negotiations, rather than the Army.

Ordeman Retirement to Bring New Jersey Standard Changes

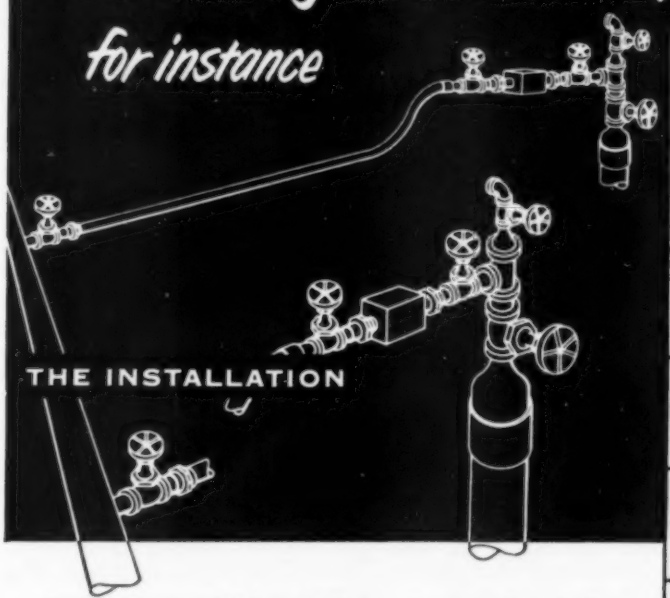
Dr. G. F. Ordeman, manager of the Wood River, Ill., refinery of Standard Oil Company (Indiana), will retire shortly on annuity. He will be succeeded in his position by H. E. Cotton, general superintendent of Standard's Casper, Wyo., refinery.

In other moves at Standard, L. H. Butterworth, manager of the Operations and Cost Control division of the Manufacturing department in the company's general office at Chicago, will be advanced to general superintendent at Casper. F. C. Smith, superintendent of the Operations and Cost Control division, will be promoted to manager.

Dr. Ordeman joined Standard in 1919 as a chemist at Whiting, Ind. After several advances, he was promoted to assistant general superintendent of the Whiting refinery in 1943, moving to manager of Wood River in 1946.

Cotton, first employed at Casper by Midwest Refining Company in 1919, went with Standard when Standard assumed the Casper refinery in 1921. He

Valve Performance that Speaks for itself ...on Well Injection Service, for instance



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THE CASE HISTORY

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More than 4 years ago, Crane No. 624E Bronze Gate Valves were put on the system. Corrosion and leakage were eliminated. Valve operation became smooth, easy, positive—the way it should be. And, ever since, that's how these Crane valves have performed. No wonder this producer, like many others, has hundreds of them in similar service.

THE VALVE

Crane No. 624E gate valves have unusually heavy metal sections and are ruggedly constructed throughout for high pressure service. Body and bonnet are of Crane Special Bronze, a high-grade leaded tin bronze. Disc is of hard, tough Crane Nickel Alloy. Better Crane quality in every detail makes them last and last. Sizes up to 2 in. rated at 1,000 psi. W.O.G. See your Crane Catalog or ask your Crane Representative for demonstration.

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was promoted to general superintendent at Casper in 1938.

Butterworth joined Standard in 1937, was transferred to the Manufacturing department in 1942 and was promoted to assistant general superintendent of the Casper refinery in 1947. He was assigned to the Chicago office in 1952.

Smith became associated with the company in 1943. He held several positions in the company before his appointment to superintendent of the Operations and Cost Control division in 1951.

Carver Gets Comptroller Post In Changes at Socony-Vacuum

W. V. Carver has been named assistant comptroller of Socony-Vacuum Oil Company, Inc. He was formerly general auditor. Other changes in the company's comptroller's department are:

G. E. Bowden, formerly assistant to the comptroller, becomes general auditor; F. T. Freitag, formerly manager of the audit department, becomes assistant general auditor; A. O. Iwen, accounting and office manager of the company's West Africa operations, and R. S. Walters, accounting and office manager of producing operations, become assistants to the comptroller in addition to their present duties.

Kellogg Honors 21 Employes For Quarter Century of Service

Twenty-one employes of The M. W. Kellogg Company were honored recently at the company's second annual Quarter Century Club dinner at the Hotel Commodore, New York. Presentation of their awards brought the club membership to 158 employes with twenty-five or more years of service, and the total years of member service to nearly 5000.

The dinner was addressed by Bennett Archambault, vice president and general manager of Kellogg, a Pullman Incorporated subsidiary, and J. E. Riley, Quarter Century Club president. A gold watch was presented by Archambault to each of the new service club members.

California Standard Employes Set Safety Record at Richmond

A new West Coast refinery safety record of 3 million man-hours without a lost-time accident has been established by employes of the Richmond, Calif., refinery of Standard Oil Company of California.

Richmond's previous safety record was 2,723,310 man-hours without a lost-time mishap. Over-all accident frequency rate for the refinery so far this year is 0.56 per million man-hours, compared to the national refinery average of 7.02.

Garrison and Dingman Get New Jefferson Chemical Posts

Lawrence J. Garrison has joined the Technical Sales Service staff of Jefferson Chemical Company, Inc., and John C. Dingman, Jr., has joined its staff as a sales representative.

Garrison has just completed a six-months' training program with the company. Dingman has spent the past eight months at Jefferson's Port Neches, Texas, plant as process engineer.

Tide Water Trains Army Officers—

Three Army officers, students in the U. S. Army Quartermaster Petroleum School, have been assigned to Tide Water Associated Oil Company to complete the last phase of their "Petroleum Analysis and Control Course." Second Lieutenant William B. Douglass, Jr., U. S. Army; Lieutenant Colonel Wang Fung, Chinese Nationalist Army; and Second Lieutenant Billy B. Kennedy, U. S. Army, shown left to right in uniforms above, are welcomed by D. L. Hines, vice president and chairman of the Eastern division operating committee of Tide Water.

Inasmuch as the program is limited to only 400 hours, the major part of the student's time will be spent at the company's Bayonne, N. J., refinery, where they will be shown general refining operations, product testing and inspection, grease and oil manufacture, utilities and maintenance, packaging, accounting and safety methods.

Gammelgard Named Manager Of Pure Oil Refinery Division

J. Porter Langfitt, senior vice president of The Pure Oil Company, has relinquished his duties as supervisor of Pure Oil's refining operations. He will continue to direct the company's Research and Development Laboratories, the Patent and the Engineering departments, and will assume general administrative responsibilities.

The company has created a new post, general manager of the Refinery division, which will be filled by P. N. Gammelgard, who has been refinery operations manager for the past four years.

Langfitt joined Pure Oil's Refining division in 1925, filling various operating jobs before entering the process department. He became vice president of refining in April, 1947.

Gammelgard went to Pure Oil in July, 1934, as a clerk in the Mechanical department of the Toledo, Ohio, refinery. In 1949 he became operations manager of the Refinery department.

In its refining division, the company announced the following promotions:

David P. Hankins, 28 years with the company and now general superintendent of the Cabin Creek, W. Va., refinery, moves to Pure Oil's Heath refinery near Newark, Ohio, where he becomes assistant to the manager. He has been in his present post for five and a half years.

Harold P. Sanders, assistant superintendent at the Cabin Creek refinery, replaces Hankins. Twenty-four years ago he began with the company as an analytical chemist.

Kenneth P. Gilson, staff assistant at Cabin Creek, becomes assistant general superintendent at Cabin Creek. He began with Pure Oil in 1934 as a laborer.

Three Tide Water Employes Win $3975 in Suggestion Awards

Tide Water Associated Oil Company has awarded its first special capital suggestion award of $1000 to John R. Barber, of the steam department at the company's Eastern division, Bayonne, N. J. Barber, one of three employes of Tide Water to be awarded a total of $3975 for having submitted the most worthy suggestions in 1952, won the special capital award for a suggestion which resulted in increasing steam boiler capacity and improving operation at the Bayonne refinery.

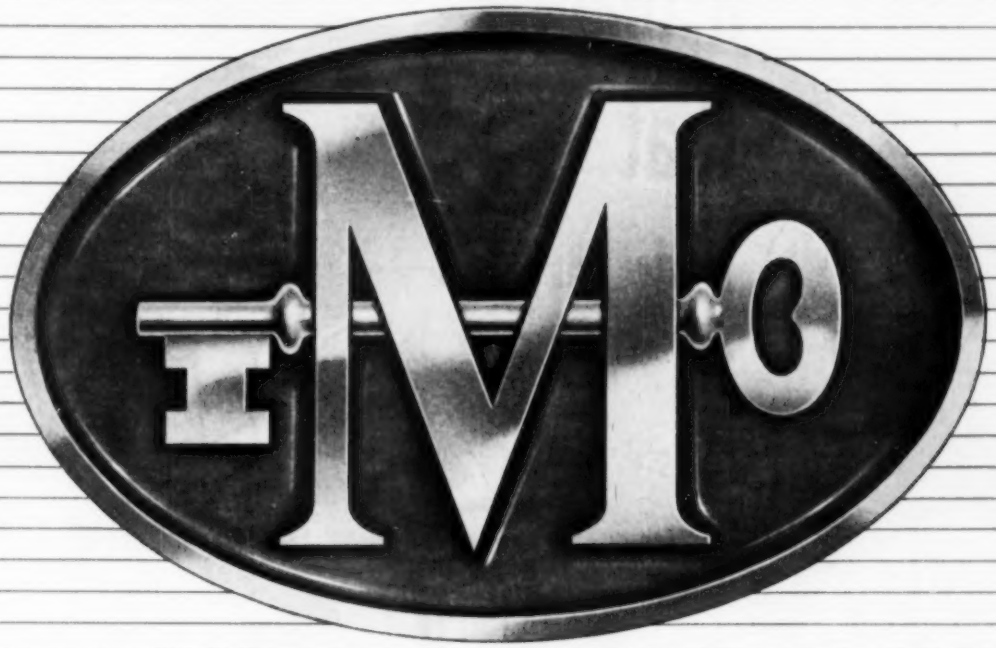
The second special capital award of $750 was presented to Western division winner Richard P. Bland, an employe of the production department at Ventura, Calif. Omer E. Irvin, a unitman at the catalytic cracking unit of the Mid-Continent division's Drumright, Okla., refinery, won the third award of $500. All three winners had previously won cash awards in their divisions. Barber, for instance, won a total of $1600.

Texaco Names Dodson Assistant To Executive Vice President

C. H. Dodson, manager of the Chicago Sales division of The Texas Company since 1950, has been named assistant to the executive vice president of the company. Ben Halsell, manager of the Boston Sales division succeeds him in Chicago.

Dodson, who started with Texaco as an engineer in 1927, has worked in both the Sales and Refining departments. He was manager of the Denver Sales division from 1942 until his appointment to Chicago.

Halsell joined The Texas Company in 1926. He became division manager, Bos-



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What's **Happening** . . .

ton, in February, 1945, and, in April of the same year, he was named assistant manager of the bulk fuel and government sales, New York. In October, 1945, he returned to Boston.

New Jersey Standard Names Myers to Coordinating Post

Norval F. Myers, managing director of Esso Petroleum Company, Ltd., London, has been appointed deputy coordinator of refining activities for Standard Oil Company (New Jersey) with headquarters in New York.

Myers

Myers has been affiliated with Esso Petroleum, the Jersey Standard affiliate formerly known as Anglo-American Oil Company, Ltd., since 1949. During that period he participated in the construction, operation and expansion of the Fawley refinery. Previously, he was assistant chief engineer of the Standard Oil Development Company, Linden, N. J., central research affiliate of Jersey Standard. He joined the development company in 1941 following 16 years experience in the petroleum industry as a research chemical engineer and in various manufacturing management capacities.

Humble Announces Additions To Staff of Baytown Refinery

The following staff additions to Humble Oil & Refining Company's Baytown, Texas, refinery have been announced:

Charles W. Bouchillon, Mississippi State College, and Arnold R. Zubik, Texas A. & M. College, to the Maintenance department of the Engineering division; Glen A. Stankis, University of California, to Research & Development division; Egbert W. Biggers, University of Illinois, Jerry G. Jenkins, Texas A. & M., William N. Lyster, Colorado School of Mines, Wayne F. Mardis, University of Alabama, Bruce A. Martin, Louisiana State University, Fred S. McDonald, Mississippi State College, and Paul D. Meek, University of Texas, to the Technical Service division.

In addition, Charles S. Lloyd, University of Florida, was reemployed on the staff of the Technical Service division after serving since 1951 in the U. S. Air Force.

California Standard Names Richmond Operations Manager

M. F. Miller has been appointed manager of operations for the Richmond, Calif., refinery of Standard Oil Company of California. He succeeds J. T. Higgins, recently elected president of two Standard subsidiaries, Salt Lake Refining Company and Salt Lake Pipe Line Company.

Miller joined Standard in 1926. Prior to his new assignment he served as assistant manager, Operations Control division, of the company's Manufacturing department in San Francisco.

Succeeding Miller will be J. S. Det-

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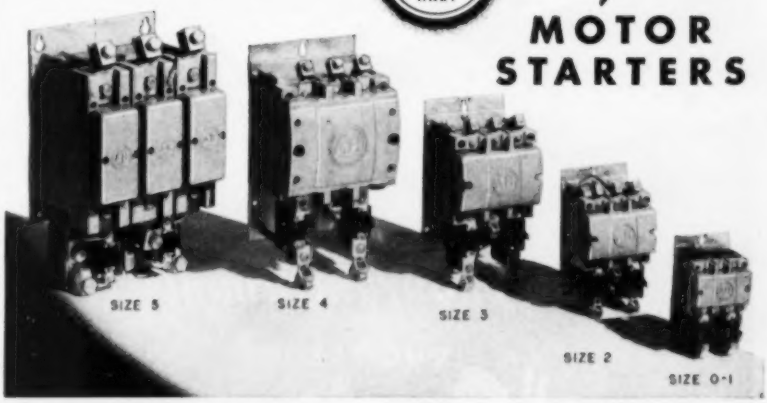

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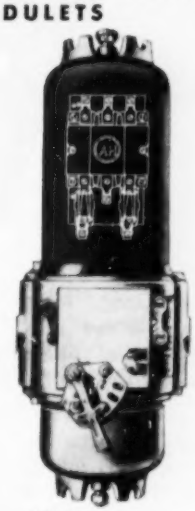

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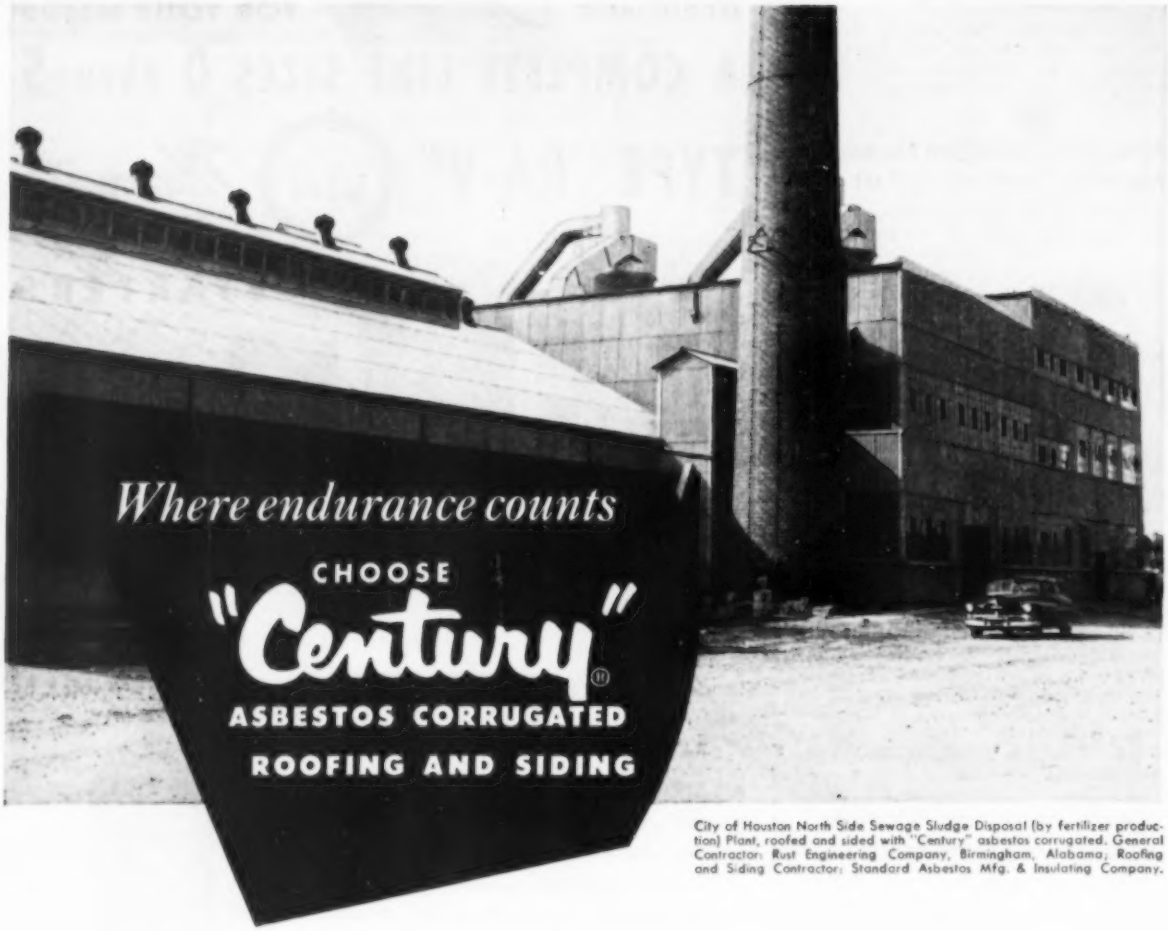

City of Houston North Side Sewage Sludge Disposal (by fertilizer production) Plant, roofed and sided with "Century" asbestos corrugated. General Contractor: Rust Engineering Company, Birmingham, Alabama; Roofing and Siding Contractor: Standard Asbestos Mfg. & Insulating Company.

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"Century" corrugated is made from asbestos fiber and portland cement, and so combines the advantages of both materials. It is strong, dense and tough. It *cannot* burn, rot, or corrode. It resists weather, vermin, and insects. And—here's an especially well-liked feature—it needs practically no maintenance during its long life, and it *never* needs protective paint. But that's not all!

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What's **Happening** . . .

weiler, who has been technical assistant in the Operations Control division, San Francisco. Detweiler joined the company in 1934.

Also appointed a new assistant manager of the same division was T. M. Sheehy, previously assistant superintendent of the Light Oil division at the El Segundo, Calif., refinery. Sheehy joined Standard in 1937.

Esso Names Perriguey to Head Sales Engineering Division

Wilbur G. Perriguey has been appointed manager of the Sales Engineering division of Esso Standard Oil Company, succeeding Walter E. Lee, recently retired. Wilbur J. Reitze succeeds Perriguey as assistant manager of the division.

Perriguey Reitze

Perriguey, who joined Esso in 1944 as senior engineer on automotive fuels and lubricants, had worked 16 years in manufacturing and development of automotive fuels and lubricants before joining Esso. Since with the company he has headed the engineering group in automotive fuels and lubricants and, since 1950, has been assistant manager of sales engineering.

Reitze joined Esso in 1934 as a technical man in the Baltimore refinery and transferrd to Standard Oil Development Company three years later. After military service, he joined Esso's Sales Engineering division in railroad lubrication. In 1947 he was named group head of the metal workindg activities, and later section head of process products and metals.

Socony-Vacuum Moves Stefanik To Foreign Trade Department

Paul Stefanik, formerly chief engineer of the chemical products group of the Lubricating department, Socony-Vacuum Oil Company, Inc., has been transferred to the lubricating and allied products staff of the company's Foreign Trade department. His new duties include coordination of chemical products activities in Europe.

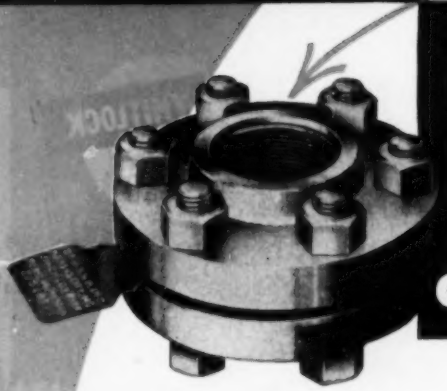
Warren A. Beman, formerly in charge of chemical development and by-products activities of the chemical products group, succeeds Stefanik as chief engineer of this group.

Los Angeles Junior College to Hold Instrument Short Course

The Third Annual Instrument Short Course, sponsored by the Los Angeles Harbor Junior College, Applied Technology division, in cooperation with the Southern California Meter Association, will be held November 19 and 20 this year. To be held on the college's cam-

QUESTION:

When does weakness mean safety?



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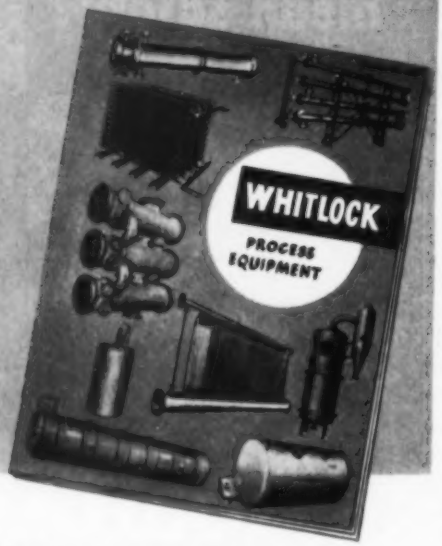
7500 East 12th Street Kansas City 26, Missouri

Big New Bulletin

...how to select the proper heat exchanger



This new Whitlock Bulletin No. 250 — just off the press — tells all about our complete line of standard heat exchangers. The bulletin shows you how to save money by selecting standard designs. It points out the characteristics of individual designs to help pick the right standard heat exchangers to meet your needs . . . and gives new tables that make it easy for you to determine sizes.

1. Eight standard types — Straight Tube, U-Tube, Double-Pipe, Coil Type, etc.
2. Complete dimensional tables, including construction details.
3. Listing of standard and special construction materials.
4. Full line of auxiliary process equipment.

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THE WHITLOCK MANUFACTURING CO.
75 SOUTH ST., HARTFORD 10, CONN.
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WHITLOCK

Whitlock designs and builds — bends, coils, condensers, coolers, heat exchangers, heaters, piping, pressure vessels, receivers, reboilers.

What's **Happening** . . .

pus at Wilmington, Calif., it will feature lectures and practical demonstrations on industrial and process instrumentation. Manufacturers will exhibit.

Higgins Appointed President Of Two Standard Subsidiaries

C. E. Finney, Jr., who is retiring as president of Salt Lake Refining Com-

Higgins Finney

pany and Salt Lake Pipe Line Company, Standard of California subsidiaries, will be succeeded by J. T. Higgins, now manager of operations at Standard's Richmond, Calif., refinery.

Finney has headed the two companies since they began operating five years ago. It was under Finney's direction that the refining company began construction of its North Salt Lake plant in 1948. He also directed construction of two major oil pipe line projects in the Salt Lake area in the past five years.

The new president of the two Standard subsidiaries has worked for Standard since 1929. After joining the company, he served as a specialist and foreman at its El Segundo, Calif., refinery until 1937. He has worked at Richmond and in San Francisco since that time.

Shell Oil Martinez Refinery Sets Safe Man-Hours Record

Two million man-hours of work without a single disabling accident has been completed at Shell Oil Company's Martinez, Calif., refinery. The period covered by the new record extends back to August 15, 1952, and is the first time the consecutive accident-free hours at the Bay Area refinery reached the 2 million mark in 38 years of operation.

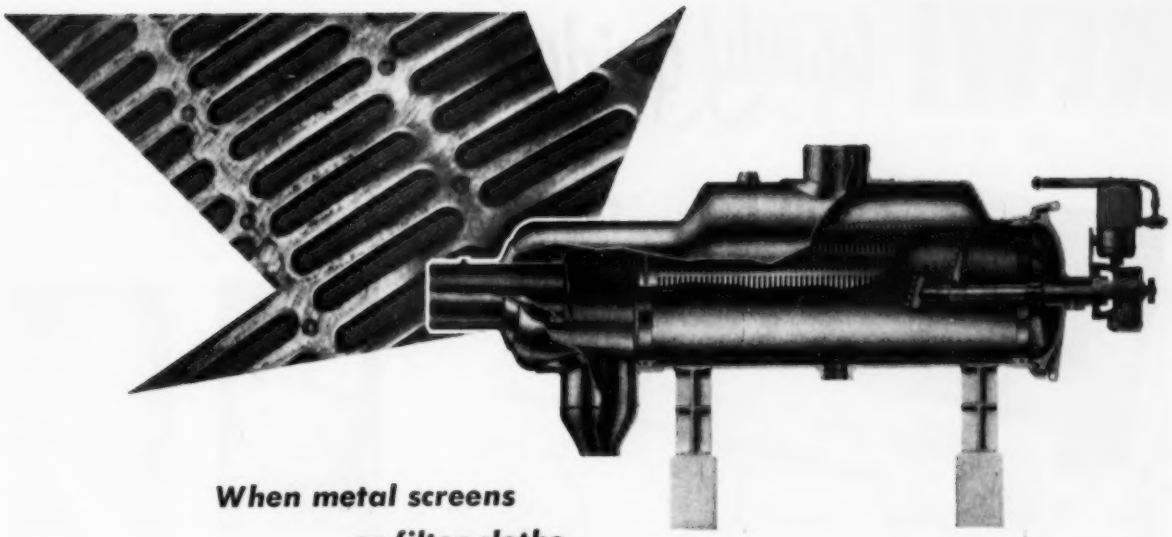
Refinery Manager John Trench congratulated the employe safety committee which assists in the planning of the refinery's safety program.

Houdry Names Smith Chief of Exploratory Research Section

Dr. Robert K. Smith has joined Houdry Process Corporation as chief of the Exploratory Research Section. Dr. Smith, at one time a senior research chemist at Standard Oil Company (New Jersey), served recently as group leader at Kendall Refining Company.

Sun Oil Fuels Authority Retires

A. Ludlow Clayden, an authority on fuels and internal combustion engines, has retired after 38 years of service with Sun Oil Company. Clayden joined Sun as chief automotive engineer in May, 1922. He became head of the automotive



When metal screens or filter cloths

"GUM UP the WORKS"...

A distinctive feature of the Jet-Type Self-Cleaning Fluid Strainer is the banks of rotating jets which are arranged inside the Monel basket to flush away built-up solids in three to five minutes... without the need to open the unit or remove the basket. Ease of cleaning makes it possible to employ a finer mesh screen, if desired, assuring a brighter product stream. For more information on this equipment, write direct to THORNHILL-CRAVER COMPANY, INC., P. O. Box 1184, Houston, Texas.

Take a tip from a well-known manufacturer of pipe line strainers and other petroleum equipment.

Several years ago, THORNHILL-CRAVER COMPANY, of Houston, Texas, set out to design a strainer that would reduce the time and labor necessary for cleaning. They wanted a strainer that could be cleaned in a matter of minutes without dismantling and that would make by-passing unnecessary. The result was the Jet-Type Self-Cleaning Fluid Strainer.

Since the advantage of a unit of this type lies in its easy, trouble-free operation, they needed a screen that would last indefinitely... that would resist abrasion by entrained solids and stand up against corrosion by the widest range of products.

Monel wire screen and cloth is widely used throughout industry wherever corrosion resistance or product purity is important – for filtering or screening chemicals, brines, alkalies... acid sludges and acidic clay-treated distillates... mud ... hydraulic oil ... for tower packing ... flame arrester screens on tank breather lines... and others.

You'll find that Monel screen and filter cloth is made in all standard weaves and meshes. It can easily be formed to almost any desired shape or size.

Whether it's a question of original equipment or replacements, take advantage of the experience of THORNHILL-CRAVER. You, too, may find that Monel is the answer to your screening or filtration problems. For information on Monel screen and filter cloth, write Inco for a copy of "Established Weavers of Monel ... Nickel ... Inconel."

It is advisable to place equipment orders with your supplier well in advance of scheduled use. Distributors of INCO Nickel Alloys can supply the latest information on availability from warehouse or mill.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

Inco Nickel Alloys

INCO **Monel**... *for minimum maintenance*

NEW! handy guide on Refinery Painting

Puzzled over painting problems? Here's a new guide that takes the guesswork out of refinery painting. In 12 easy-to-read pages, with painting recommendations in handy check chart form, it tells at a glance the right paint to use on each type of interior or exterior surface—for surfaces exposed to various temperatures and operating conditions.

Included are suggestions on surface preparation and helpful painting hints.

Ask for your copy . . . write for Brochure A-770. The Sherwin-Williams Co., Petroleum Division, Cleveland 1, Ohio.

SHERWIN-WILLIAMS
PETROLEUM FINISHES

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What's **Happening** . . .

laboratory at the Marcus Hook, Pa., refinery in 1948, and, in February of this year, he became technical associate in the Chemical Research and Development department.

Four Get New Posts in Changes At Esso Standard Oil, S.A.

L. J. Brewer has been elected a member of the board of directors of Esso

Patrick

Brewer

Griffin

Fourrier

Standard Oil, S.A. He was formerly manager of the company's Cuba operations. Also, in additions to his responsibilities with the Cuba operations, he has recently carried out special assignments in other areas of the company.

As a result of Brewer's election other changes have been announced by the company. W. I. Patrick, assistant manager of the company's Cuba operations, will succeed Brewer as manager and replace him as a vice president of Esso Standard Oil, S.A. C. J. Griffin, manager of the Esso Belot refinery, has been appointed assistant manager of the Cuba operations, and F. L. Fourrier, assistant manager of the refinery, succeeds Griffin as manager.

Gill Named Purchasing Agent

Sunray Oil Corporation has named Perry A. Gill, North and West Texas district production superintendent, purchasing agent for the company. He will go to the company's general offices in Tulsa to set up a centralized purchasing department to handle all phases of the company's equipment and supply purchasing.

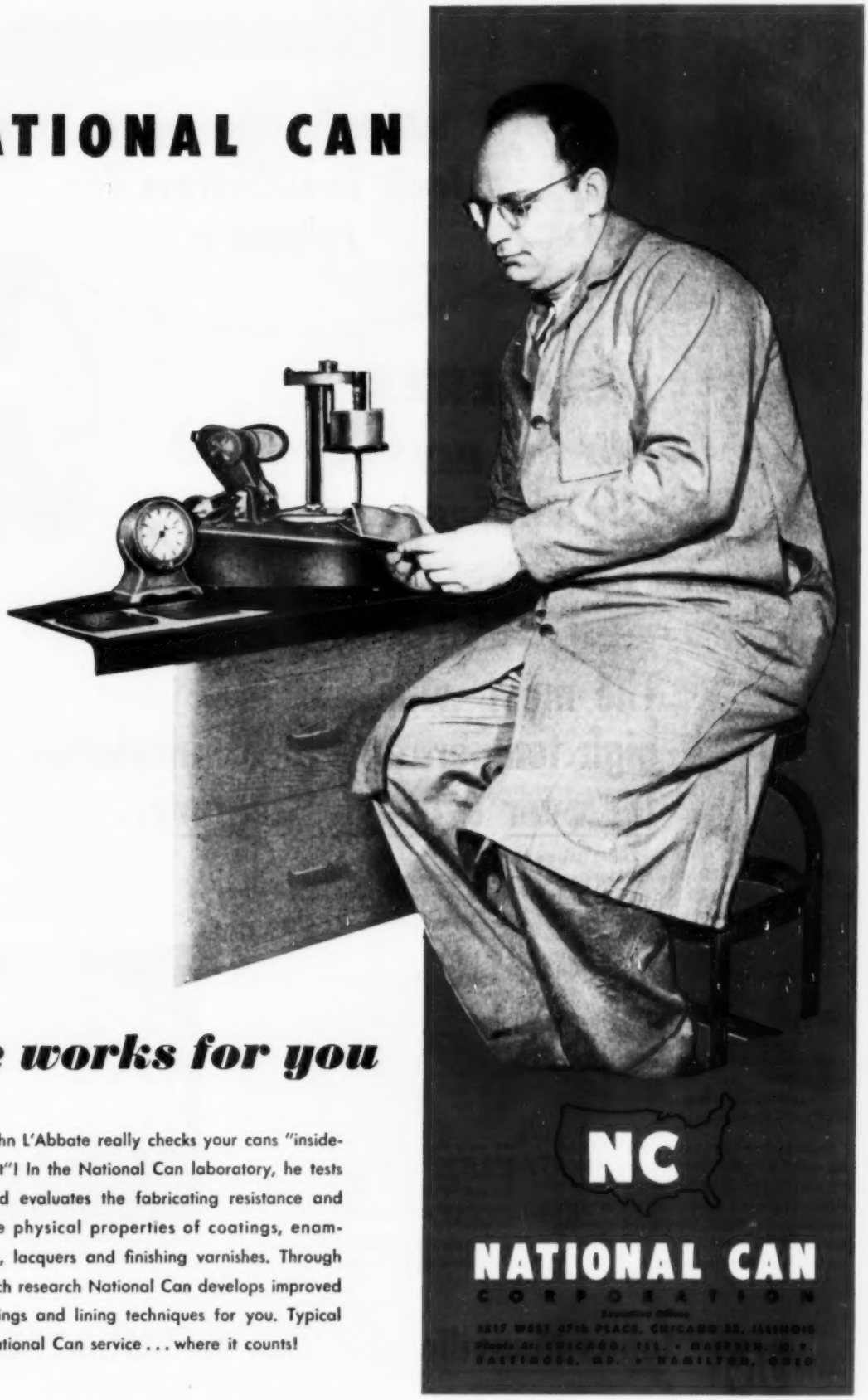
Grace Chemical Names Skinner

Loren C. Skinner has been named chief engineer of Grace Chemical Company's $19 million nitrogen plant now under construction near Memphis, Tenn. Skinner was formerly chief of the Engineering and Design department of the U. S. Bureau of Mine's Synthetic Fuels Demonstration plant at Louisiana, Mo.

As chief engineer of Grace Chemical's

at

NATIONAL CAN



he works for you

John L'Abbate really checks your cans "inside-out"! In the National Can laboratory, he tests and evaluates the fabricating resistance and the physical properties of coatings, enamels, lacquers and finishing varnishes. Through such research National Can develops improved linings and lining techniques for you. Typical National Can service . . . where it counts!

NC

NATIONAL CAN

CORPORATION

The most widely used high temperature block insulation for over a quarter century...

SUPEREX® high temperature block insulation has long been industry's No. 1 choice for service temperatures up to 1900F. It provides *major* economies . . . reduces fuel costs, cuts heat losses, keeps maintenance expense down, costs less to install and has long service life.

Made of specially selected and calcined diatomaceous silica blended with other insulating materials and bonded with asbestos fiber, Superex will safely withstand temperatures up to 1900F with negligible shrinkage.

Superex has been used with outstanding success in all types of ovens, stationary and marine boilers, auxiliary power plant equipment, stills, reactor chambers, regenerators, high temperature mains, heaters, flues, stacks, and other types of high temperature equipment.

Superex has all these important advantages...

Low thermal conductivity—Exceptionally high heat resistance (1900F) combined with excellent insulating value.

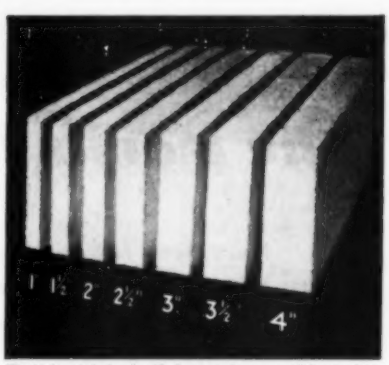
Light weight—Approximately 2 lb per sq ft per in. thickness.

Great physical strength—Approximately 6 tons pressure per sq ft are required to compress Superex ½ in.

Long, efficient service life—Superex maintains high insulating value indefinitely—will not disintegrate in the service for which it is recommended.

Fast, easy application—Superex may be cut with an ordinary knife or saw for fitting around openings or to irregular surfaces. Because of its light weight and convenient sizes, Superex assures fast and economical installations.

For complete information about Superex block insulation, write for Brochure IN-134A. Address Johns-Manville, Box 60, New York 16, N. Y. In Canada, write 199 Bay Street, Toronto 1, Ontario.



Waste is minimized with Superex because of the variety of thicknesses available. Special shapes and intermediate thicknesses between those shown are also available.

JOHNS-MANVILLE JM PRODUCTS **Johns-Manville** *first in* **INSULATIONS**

Memphis plant, he will be responsible for all phases of maintenance and for future plant design and construction.

Arnold Named Superintendent Of Vickers Potwin Refinery

Vickers Petroleum Company, Inc., has announced the appointment of T. Ben Arnold as superintendent of its refinery at Potwin, Kan.

Arnold

For the past three years Arnold has been chief engineer and manager of the Refinery division of Southwestern Engineering Company of Los Angeles. In his former position he was in charge of construction and installation of the new Vickers TCC unit that went on stream last March.

A. M. Schrepfer, vice president of manufacturing for Vickers will continue in charge of over-all refinery operations.

Ethyl Subsidiary Promotes Philp to Assistant Manager

Promotion of Howard J. Philp to assistant manager has been announced by Ethyl Antiknock, Ltd., Ethyl Corporation's Canadian subsidiary.

Since joining Ethyl Antiknock as a sales representative in 1949, Philp has worked closely with petroleum refiners throughout eastern Canada, assisting them in making the most effective use of "Ethyl" antiknock compounds.

Prior to joining Ethyl Antiknock, Philp was assistant general manager for Eastern Steel Products, Ltd., for three years; manager of wholesale and industrial sales for Sun Oil Company, Ltd., for eight years, and with Massey-Harris Company, Ltd., for 12 years.

Walter Kidde Constructors Names Whitney Chief Engineer

F. L. Whitney, formerly Eastern district chief engineer for The H. K. Ferguson Company, has been appointed chief engineer of Walter Kidde Constructors, Inc. He had been associated with Ferguson in charge of design for numerous major industrial projects for 13 years.

Whitney was recently honored by the Museum of Modern Art as designer of one of the outstanding structures erected in the U. S. since the end of World War II. He has received international recognition for his design of Corn Products Refining Company's Bluebonnet plant at Corpus Christi, Texas.

Hauck and Alexander Named in Blaw-Knox Division Promotions

Two promotions in its sales personnel have been announced by Blaw-Knox Company's Chemical Plants division.

Charles F. Hauck has been advanced to sales manager of the division. He is succeeded as assistant sales manager by Bruce Alexander.

Hauck joined Blaw-Knox in 1951 as

THINGS TO LOOK FOR WHEN YOU BUY FLOOR PLATE

LOOK *at the Raised Pattern!*

All steel floor plates have raised figures. Only one—A. W. SUPER-DIAMOND—has the *safety pattern* you see here. Note the over-all pattern of clear-cut diamond treads. It means real foot-safety, first requisite-in floor plate.

LOOK *at the Protection!*

SUPER-DIAMOND puts 40 diamond treads in every footstep—40 traction points to keep feet safe and secure. Every SUPER-DIAMOND grips hard for maximum skid-resistance, regardless of the angle of approach.

LOOK *at the Savings!*

First cost is low and so is maintenance—with A. W. SUPER-DIAMOND. The over-all SUPER-DIAMOND pattern permits cutting with minimum waste—provides perfect matching end-to-end or side-by-side. And SUPER-DIAMOND needs no maintenance other than cleaning.

LOOK *at the Service!*

SUPER-DIAMOND installations are permanent. Years of abuse won't wear out this tough, rolled steel floor plate. It withstands hard blows and heavy loads without cracking or breaking. And it's resistant to oil, heat and fire.

LOOK *at the Easy Cleaning!*

SUPER-DIAMOND'S exclusive pattern means no cracks or joints to hold dirt. The surface is easily cleaned with broom, mop or hose—dries fast after washing—can be painted if you so desire

For safety with economy on factory floors, ramps, trench covers, walkways, get full information about A. W. SUPER-DIAMOND Rolled Steel Floor Plate. We'll be glad to send you complete technical data and suggestions for use. Simply clip and mail the handy coupon.

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ROLLED STEEL FLOOR PLATE
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Other products: A. W. ALGRIP Abrasive Rolled Steel Floor Plate • Plates • Sheets • Strip (Alloy and Special Grades).

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No magic... No magnetism... lapped wring fit of every Okadee Valve disc and seat must pass this test of a perfect sealing surface. (unretouched photo)

...Here's What it Means to You in Terms of Valve Service

Flat mating surfaces within .000005", or less, of every set of Okadee valve discs and seats mean absolute shut-off of any material from ammonia gas to asphalt.

How long does this seal last in service? We honestly don't know. Tests under working conditions with propane were stopped after 269,000 operating cycles when no wear or seal failure could be detected. And Okadee valves do not have to be babied in service on corrosive or abrasive materials . . . Thousands of boilers have had Okadee blow-down valves in continuous, trouble-free service for fifteen years or more. If Okadee size-pressure-temperature ranges include your valve applications, Okadee installation will end your problems of valve performance once and for all.

Okadee valves are available in single-disc (one direction) and double-disc (two directions) types; screwed or flanged; ½" to 6" in standard A.S.A. dimensions; steel or semi-steel bodies (other materials to order); stainless steel or stellite seat facings; levers, rack-and-lever, worm-gear, hydraulic, pneumatic, automatic on-off control.

Write for Bulletin 332-G today!

OKd. Okadee COMPANY
332 South Michigan Avenue • Chicago 4, Illinois

What's **Happening** . . .

manager of sales promotion in the Chemical Plants division, later advancing to assistant sales manager. Alexander, with the company since 1944, was for three years in charge of sales and engineering of process equipment for the Blaw-Knox Equipment division at Blawnox, Pa.

Oostermeyer Elected Member Of Fluor Board of Directors

Jan Oostermeyer, former president of Shell Chemical Corporation, has been elected to the board of directors of The Fluor Corporation, Ltd., of Los Angeles. His election brought the number of board members to ten.

Oostermeyer

Oostermeyer's retirement from Shell was announced last June. He spent 20 years in the Orient, where he was with Asiatic Petroleum Company, before becoming assistant manager for Shell at Santiago, Chile, in 1937. Shell Chemical Corporation was recreated in 1946 as a separate and autonomous concern with Oostermeyer as president.

The new Fluor director was responsible for and guided the $50 million Shell petrochemicals expansion program, for which Shell was awarded the Chemical Engineering Achievement Award in 1948.

AIChE Names Michigan Dean Treasurer Succeeding DeLong

George Granger Brown, dean of the College of Engineering at the University of Michigan, has been appointed treasurer of the American Institute of Chemical Engineers. He was appointed to fill out the term of treasurer held by C. R. DeLong, vice president of North American Solvay, Inc., and Solvay American Corporation. DeLong had held the post since 1936.

A former president of AIChE, Dr. Brown holds the Institute's William H. Walker Award and the Hanlon Award of the National Gas Association.

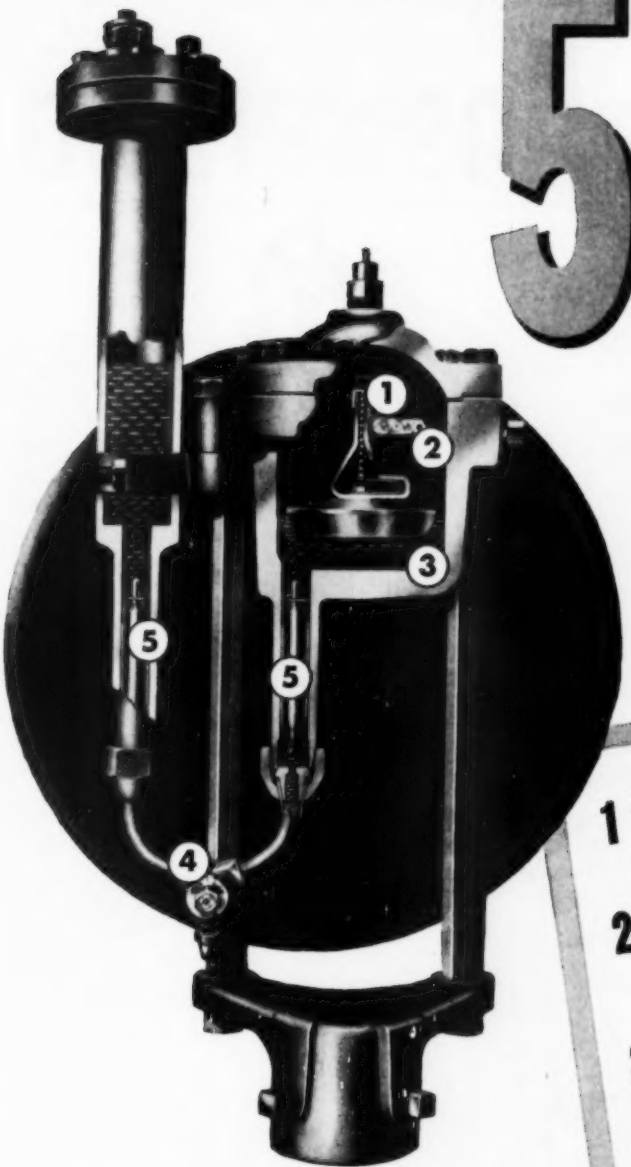
Humble Schedules New Series Of Lectures at Baytown Plant

Another series of lectures similar to the Humble Lectures in Science will be offered to the engineers of Humble Oil & Refining Company at Baytown, Texas. This series will be known as the Humble Lectures in Engineering.

Professor Stephen H. Crandall, of the Mechanical Engineering department of Massachusetts Institute of Technology, will present the first course in the new lecture series at the refinery.

AIEE Fall General Meeting Will Emphasize Power Uses

Uses of electric power in the petroleum industry will be emphasized in the Fall General Meeting of the American Institute of Electrical Engineers in the Hotel Muehlebach, Kansas City, Mo., November 2-6.



5 basic advances that mean BETTER FLOW METERING!

1 **New Segmental Drive Assembly** — stainless steel ball-type chain insures perfect alignment and friction-free travel of float.

2 **New Pressure-Seal Bearing** — stainless steel with exclusive seal ring . . . gives unmatched freedom at any working pressure from friction, maintenance and leaks. No lubrication required.

3 **New Compact Float Chamber** — greater accessibility for easier, quicker cleaning.

4 **New U-Bend and Damping Plug Assembly** — self-aligning, all-welded construction . . . no gaskets required. Calibrated damping plug fully adjustable under pressure. Directed drain for mercury at lowest point.

5 **New Check Floats** — with positive-seating stainless steel ball plug. Submerged in mercury for complete protection against dirt and corrosion.

With major improvements in every basic detail, the complete new line of Foxboro Flow Meters now gives metering performance that's farther ahead of the field than ever before!

In addition to the outstanding advances illustrated, these new meters incorporate many other superior features, including: interchangeable parts; large floats with long travel for added power; and float in high pressure chamber to minimize ambient temperature effects.

Write for new Bulletin 460. It describes the complete new line . . . indicators, recorders, controllers, transmitters . . . with round or rectangular cases . . . with and without integrators. The Foxboro Company, 747 Neponset Ave., Foxboro, Mass.. U.S.A.

FOXBORO
Reg. U.S. Pat. Off.
First in FLOW METERS

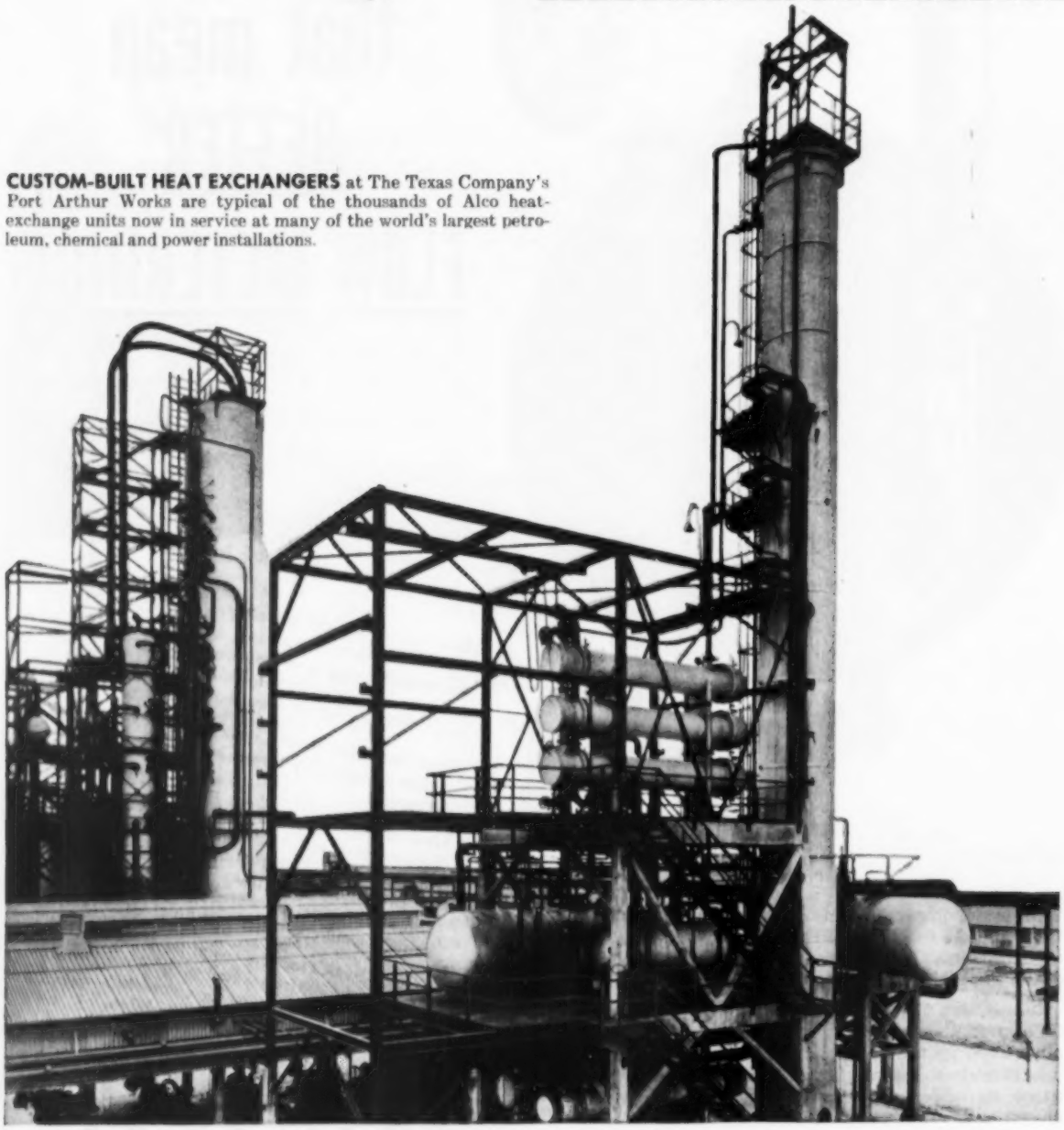
FACTORIES IN THE UNITED STATES, CANADA AND ENGLAND

demanded by growth and

Alco

Answers to

CUSTOM-BUILT HEAT EXCHANGERS at The Texas Company's Port Arthur Works are typical of the thousands of Alco heat-exchange units now in service at many of the world's largest petroleum, chemical and power installations.



Hundreds of new industrial problems call for new and varied types of heavy metal equipment. More and more frequently, the answers are designed and built by Alco.

Alco's experience in the heavy equipment field is unsurpassed. You will find Alco products today in power, petroleum, chemical and manufacturing plants all over the world.

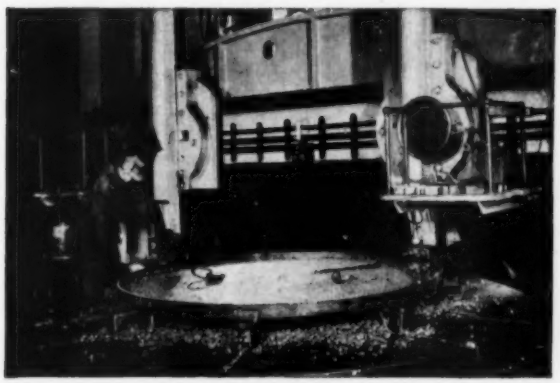
Alco's production and testing facilities are modern and complete. At the 31-acre Alco plant at Dunkirk, N. Y., the most difficult of metal-fabricating operations are handled with maximum speed and efficiency.

If your own industrial problems call for the kind of heavy metal equipment you see on these pages—the kind that can meet your strictest specifications—send the details to your nearest Alco Products Sales Engineer.

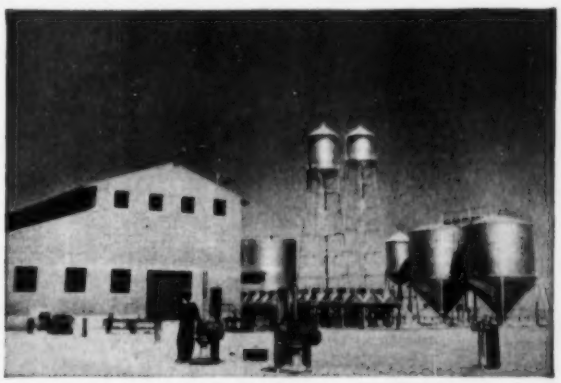
You will find him at New York, Chicago, Los Angeles, Kansas City, Houston, Tulsa or Beaumont. Or write direct to Dunkirk.

progress...designed and built by Alco

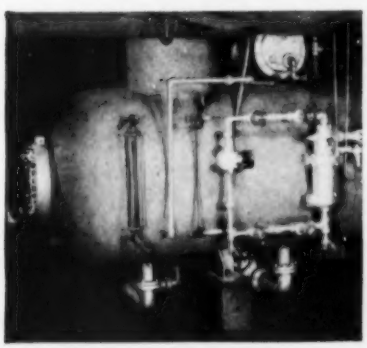
New Industrial Problems



LARGE DIAMETER BORING MILL at Alco's recently expanded Dunkirk plant is equipped with heads for both straight and bevel work. This is one of the many special machines that enable Alco to produce efficient, economical answers to hundreds of new industrial problems.

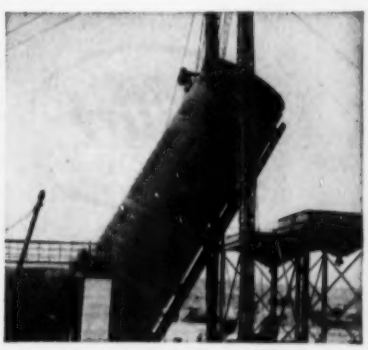


21 ALCO AIRCOOLERS handle all water cooling requirements at each of four pumping stations on the Trans-Arabian Pipe Line—with ambient temperatures as high as 122 F! Available in either radiator-core or fin-tube types, Alco Aircoolers offer a means to lower cooling costs for scores of applications.



FLEX-TUBE EVAPORATOR at New York State Electric and Gas Corporation's Hickling Station was designed and built by Alco to produce vapor under controlled conditions, of not more than 0.5 parts of total solids. Patented Flex-Tube construction greatly facilitates removal of scale.

25,000 FT OF ALCO STEEL PIPE help furnish the Arnold Engineering Development Center of the USAF with 100,000 gallons of cooling water per minute. Over the years, Alco has produced pipe of all shapes, sizes and materials for many of the largest industrial and municipal piping installations.



125-TON REGENERATORS for El Paso Natural Gas Company's new gas-turbine pumping installation are 10 ft in diameter, 33 ft long and contain over 5000 tubes. Units like these illustrate the wide range of special heavy-metal equipment designed and fabricated by Alco to meet virtually any specifications.

ALCO

ALCO PRODUCTS DIVISION

AMERICAN LOCOMOTIVE COMPANY • DUNKIRK, NEW YORK

PRECISION MADE

Norris Quality Swaged Nipples ... and smaller ... in SAE 8... alloy steel for special refi... and chemical plant ser...

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WHO'S Building . . .

Tanks and Towers for Belgium —

Storage tanks and cracking towers expand the industrial skyline of Belgium's low lands as a new refinery of a Standard Oil Company (New Jersey) affiliate goes on stream at Antwerp. The plant of Esso Standard Refinery, S.A., scheduled for formal opening September 8, will have a crude oil capacity of 25,000 barrels a day in producing motor fuels and heating oils. Its $25 million cost was financed entirely by private capital. Features of the Antwerp refinery, situated on a 190-acre site along the Schelde River, include the latest design in Fluid catalytic cracking equipment, integral docks for tankers and facilities for direct delivery of bunker fuel to ships.

This photo shows a general view of the refinery.

Plans to Build Refinery in Puerto Rico Announced Twice

The option held by Rear Admiral A. F. Carter to purchase Puerto Rican Oil Refining Company expired "several months ago," so F. E. Lyford and William Eberle, who organized the company, "are going along on our own," Eberle announced last month. "We are convinced he is not interested in going along with us," he said. The company plans to build a 20-30,000-barrel-a-day refinery in Puerto Rico and has several sites under consideration.

A few days after the announcement by Eberle, however, Carter made his own announcement. He said that Commonwealth Oil Refining Company, of which he is a principal, has purchased a 450-acre refinery site on the southwest corner of Puerto Rico near Ponce.

PAD Revises Estimates

Continued from Page 94

new refining capacity is scheduled to be completed after January 1, 1955, the estimates indicate.

Refining capacity on January 1, 1953, is estimated by PAD at more than 7,700,700 barrels a day.

These estimates represent a revision, on the basis of more recent information, of estimates originally issued on December 12, 1952. The new figures have been adjusted to cover revisions in estimated completion dates of refining facilities planned or under construction, and include new projects reported to PAD subsequent to December 12. Some adjustments have been made also to bring the figures into conformity with Bureau of Mines statistics.

AIOC and Petrofina Plan Antwerp Refinery Expansion

Cie. Industrielle des Petroles (Petrofina and Anglo-Iranian Oil Company) will add catalytic cracking and catalytic polymerization units to its Antwerp refinery. Opened only in September, 1951, the refinery processed nearly 36,000 barrels a day last year. The additional construction planned calls for modification of the thermal cracking unit to permit charging an additional 17,000 barrels of crude daily.

As previously reported by Anglo-Irianian (PETROLEUM REFINER, May, page 109), improvements will be carried out at three refineries in continental Europe which are owned by company affiliates.

In Germany, a new distillation unit is to be installed at the Hamburg refinery to raise daily distillation from slightly more than 13,000 barrels a day to about 24,000 barrels a day.

At the nearby Schindler refinery, the production of high-quality lubricating oil will be increased by the introduction of a new furfural treating plant.

In France, plans call for construction of a 5000-barrel-a-day platformer at the Dunkirk refinery of Societe Generale des Huiles de Petrole.

Anacortes May be Site for New Shell Washington Refinery

Shell Oil Company has reported that Anacortes, Wash., is the likely location for its proposed 50,000-barrel-a-day refinery.

A Shell representative said that the proposed plant will be one of the most modern in the nation, complete with a catalytic cracker and reforming units. He indicated the actual construction is some time off.

California Standard Plans $10 Million Vancouver Plant

Plans to construct a new $10 million refinery near Vancouver, B. C., have been announced by Standard Oil Company of California. Designed to utilize Canadian crude oil, the new plant will be constructed and operated by Standard Oil Company of British Columbia, a wholly-owned subsidiary.

Construction is expected to begin immediately, with completion of the refinery scheduled for the end of 1954. The new plant will be built on a site adjacent to the company's presently operated refinery at Burnaby, near the western terminal of Trans Mountain Pipe Line, now being completed from the Alberta oil fields.

On its completion, the refinery will process about 11,000 barrels of Alberta crude daily to make aviation and motor gasoline, as well as asphalt and fuel, diesel and heating oils.

Major units of the new refinery will include catalytic cracking and polymerization facilities, as well as a two-stage crude distillation unit.

Pan American Refining Weighs Possible Sites for Refinery

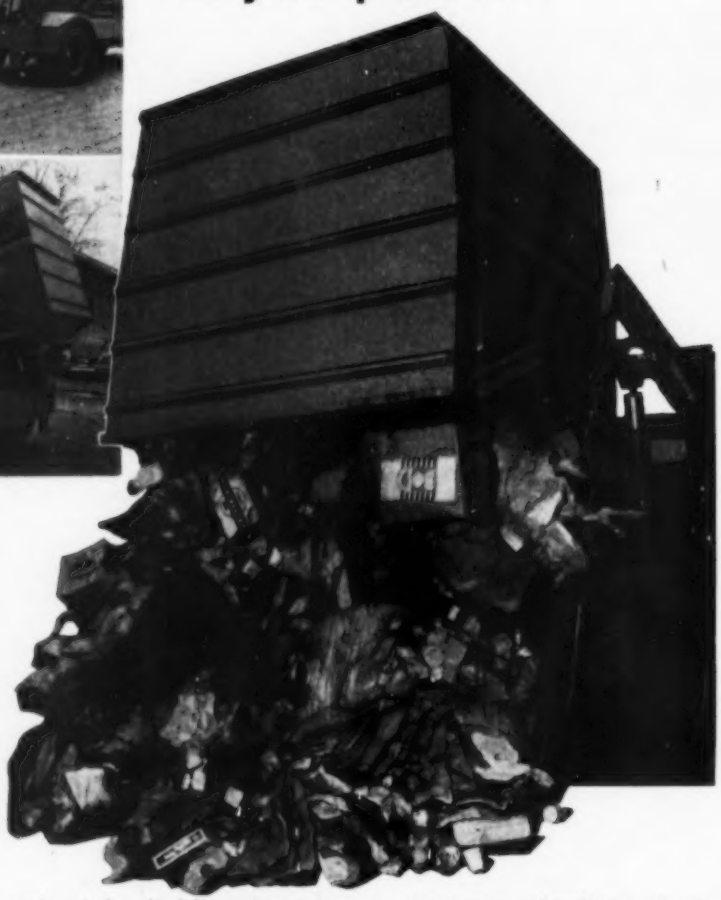
Two sites being considered by Pan American Refining Corporation for construction of an East Coast refinery are Pedricktown, N. J., and Portsmouth, R. I. The Company is holding in obeyance its final decision as to the refinery location, pending completion of engineering studies of the sites.

The company was issued a certificate of necessity to build near Pedricktown, and the Rhode Island legislature has passed a bill permitting Portsmouth to license the manufacture of petroleum products.

Cities Service Gasoline Plant Put in Operation at Blackwell

Cities Service Oil Company's 200,000-gallon-a-day gasoline plant near Blackwell, Okla., has been placed in operation. Daily output of the unit will in-

Rubbish Disposal is only ONE of the Cost Cutting jobs for the Dempster-Dumpster in your plant...



It's amazing, almost to the point of fantasy, yet so soundly real, what the minds of men in all types of industry have cooked up for more efficiency and reduced costs with the Dempster-Dumpster.

Hundreds of plants are handling materials of practically every description with one truck-mounted Dempster-Dumpster serving scores of detachable containers. Here are just a few. Oils, gases, and liquids handled in our Tank Type Containers . . . tools and equipment in our Tool Shed Type Container . . . containers on casters placed for receiving steel chips from lathes or at conveyors for receiving finished products . . . container with doors and windows, replacing shacks for plant guards or nightwatchmen . . . containers built to handle chlorinator ash residue of approximately 1500° F. and there are dozens more.

Containers are placed wherever material accumulates. When loaded each is picked-up, hauled and emptied (as illustrated above) . . . or load set down intact. The entire operation is handled by only one man, the driver, by hydraulic controls in cab.

The containers are built in capacities up to 12 cu. yds. and each is designed to suit the materials to be handled—be they bulky, light or heavy . . . solids, liquids or dust.

One Dempster-Dumpster, with driver, does the work of 3 to 5 conventional trucks . . . eliminates trucks and crews standing idle . . . eliminates rehandling of materials and increases efficiency and good plantkeeping.

If you have even any remote idea that this equipment could be adapted to your operation, by all means contact us because being without the Dempster-Dumpster System could easily be costing your company thousands of dollars annually. Manufactured and sold exclusively by Dempster Brothers, Inc.

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clude 57,000 gallons of natural gasoline, 125,000 gallons of LPG, and 20,000 gallons of isobutanes.

Cities Service Ups Capacity At Lake Charles Refinery

Crude thruput capacity will be increased by about 25,000 barrels a day at Cities Service Refining Corporation's Lake Charles, La., plant when a $20 million expansion program is completed in 1954. In addition, new and revamped units will produce maximum economic yield of 100/130 and 115/145 grade aviation gasolines and high quality motor gasoline, as well as other conventional refinery products.

Another objective of the expansion program is increased flexibility of operations.

First construction in the program began in May, 1952, and included additions to the topping units, deasphalting unit, catalytic cracking units, power house, revamping of the acid plant, fractionation and gas recovery unit for the catalytic cracking units, and alkylation units.

Under construction are a new vacuum unit, hydroformer feed preparation unit and a fluid hydroforming unit. Additional tankage, cooling towers and other general facilities are included in the program.

Harpener Bergbau Completes New Benzol Plant in Germany

A new plant for refining high purity benzol under pressure has been opened by Harpener Bergbau A. G. at Dusseldorf, Germany. Monthly processing capacity will be between 5000 and 6000 tons. The producing method was developed by Scholven Chemie A. G. to avoid heavy losses during refining.

Mid-Continent Starts Work on West Tulsa Cat Reforming Unit

Work is underway at Mid-Continent Petroleum Corporation's West Tulsa refinery on the construction of a new $2.5 million catalytic reforming process unit. The new unit will have a capacity of 7500 barrels a day of straight run gasoline charging stock with a yield of 72,000 barrels a day of high octane gasoline.

With the completion of its catalytic cracking unit in 1949, Mid-Continent has spent approximately $20 million at its West Tulsa refinery in new and improved equipment. The reforming process used in the new unit is licensed by Atlantic Refining Company, which developed it. The M. W. Kellog Company will engineer and build the new unit.

National Distillers to Produce Synthetic Ammonia at Tuscola

A new plant for the production of synthetic ammonia and fertilizer nitrogen compounds will be built at Tuscola, Ill., by National Distillers Products Corporation.

Production capacity of the plant will be 50,000 tons a year of anhydrous ammonia. The project will include facilities for the conversion of part of the ammonia into nitric acid which will be transformed into ammonium nitrate by

One of many reasons why skilled industrial maintenance men prefer the

AIRETOOL TUBE EXPANSION CONTROL SYSTEM

rolls tube joints tight automatically

Now science replaces "sensitive feel" in tube rolling! The AIRETOOL Tube Expansion Control System eliminates danger of over or under expansion. It automatically regulates the amount of expansion, produces maximum tightness and holding strength in every tube joint! With this system you can actually cut tube rolling time in half! Easy to use. Set dial for tube size, insert ball bearing expander and start powerful motor. When the tube joint reaches proper expansion and tightness, the control automatically shuts off the power. For more information and a convincing demonstration, write to:

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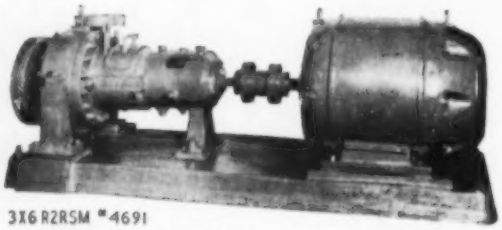
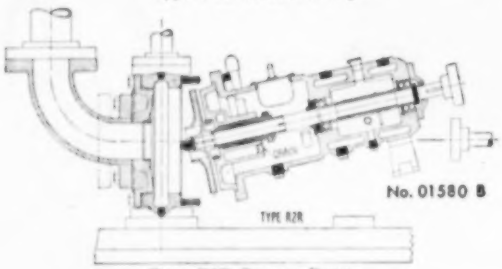
DEAN BROTHERS PUMPS INC.

Type R2R Centrifugal Process Pumps



Type R2R Process Pump



Type R2R Process Pump

DISASSEMBLY: The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

OPERATING RANGE: Type R2R. Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.
Capacities: 50 to 2600 Gallons per minute. Heads: Up to 400'. Speeds: 900 RPM to 4000 RPM.

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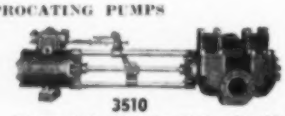
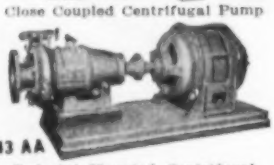
CENTRIFUGAL and RECIPROCATING PUMPS

Close Coupled Centrifugal Pump

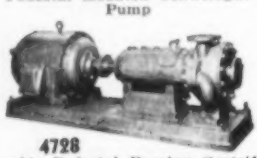


3510
Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids



4043 AA
Pedestal Mounted Centrifugal Pump

3833
Horizontal, Duplex, Double Acting, Side Pot, Piston Type, Oil Bath Power Pump



4728
Double Pedestal Bearing Centrifugal Pump

3556
Durable Duplex Packed Piston Pattern Steam Pump, Side Pot Type

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reaction with more ammonia.

Total cost of the project will be about $7 million. Completion is scheduled for January, 1955.

New Esso Standard Refinery Starts Operations at Antwerp

Esso Standard's new refinery near Antwerp, Belgium, will begin experimental operations this month, with formal opening expected in the latter part of August.

With a daily thruput of 25,000 barrels, the refinery will provide the Benelux countries with additional local supplies of premium and regular gasoline, kerosine, industrial fuels and heavy bunker fuel oils.

Planned to process crude petroleum from the Middle East fields, the new refinery is being built and will be operated by S. A. Esso Standard Refinery, an affiliate of Standard Oil Company (New Jersey).

First Socony-Vacuum TCR Unit Under Construction at Augusta

Construction has begun on Socony-Vacuum Oil Company's first TCR—Thermofor catalytic reforming—unit at its Augusta, Kan., refinery. Design and construction of the unit is being handled by Bechtel Corporation.

The TCR unit will have a 3000-barrel-a-day charge capacity, and is one of three the company is installing. Each of the other two will have a 19,000-barrel-a-day capacity and will be installed at subsidiary company refineries. One will be built at General Petroleum Corporation's Torrance, Calif., plant and the other at Magnolia Petroleum Company's Beaumont, Texas, refinery.

Shell of Canada Will Build Sulfur Plant, Plans Refinery

Plans to build a sulfur extraction plant at Okotoks, Canada, southeast of Calgary have been disclosed by Shell Oil Company of Canada, Ltd. The company also revealed that it is contemplating construction of a 50,000-barrel-a-day oil refinery on the U. S. Pacific Coast which will use Alberta oil.

The planned sulfur extraction plant is for the company's highly sulfurous gas field at Okotoks. Plans for the Okotoks plant have not been finalized yet and will depend, to a large extent, on current drilling in the area. Estimated cost of the plant was not disclosed.

Location or cost of the proposed U. S. Pacific Coast oil refinery likewise was not made known.

Warren Petroleum to Start Work on Natural Gasoline Unit

Construction will be started this month on Warren Petroleum Corporation's Saunders natural gasoline plant, located approximately 17 miles northwest of Lovington, N. M. Completion of the unit is scheduled for February, 1954. The Fluor Corporation, Ltd., has the contract to build the plant.

Initial installation will include facilities to gather and process approximately 22 Mmcf of gas daily, with a daily average production of 30,000 gallons of natural gasoline, 15,000 gallons of butane,

Cities Service Geologist Maurice Kennedy, in West Texas

Where's the next gas station?

WOULDN'T THIS OIL MAN like to know! It would certainly make his life simpler if nature posted signs: "Gas and Oil 10,000 Feet Below."

Nature, of course, gives hints as to where her huge underground hoards of oil may be stashed away ... rock outcrops may provide the clue to sub-surface structures and reservoirs.

These are not only difficult to read, they are often downright misleading. It's a gigantic treasure hunt—made even more difficult by false clues!

Every day thousands on thousands of motorists drive into Cities Service stations and say, "Fill 'er up!"

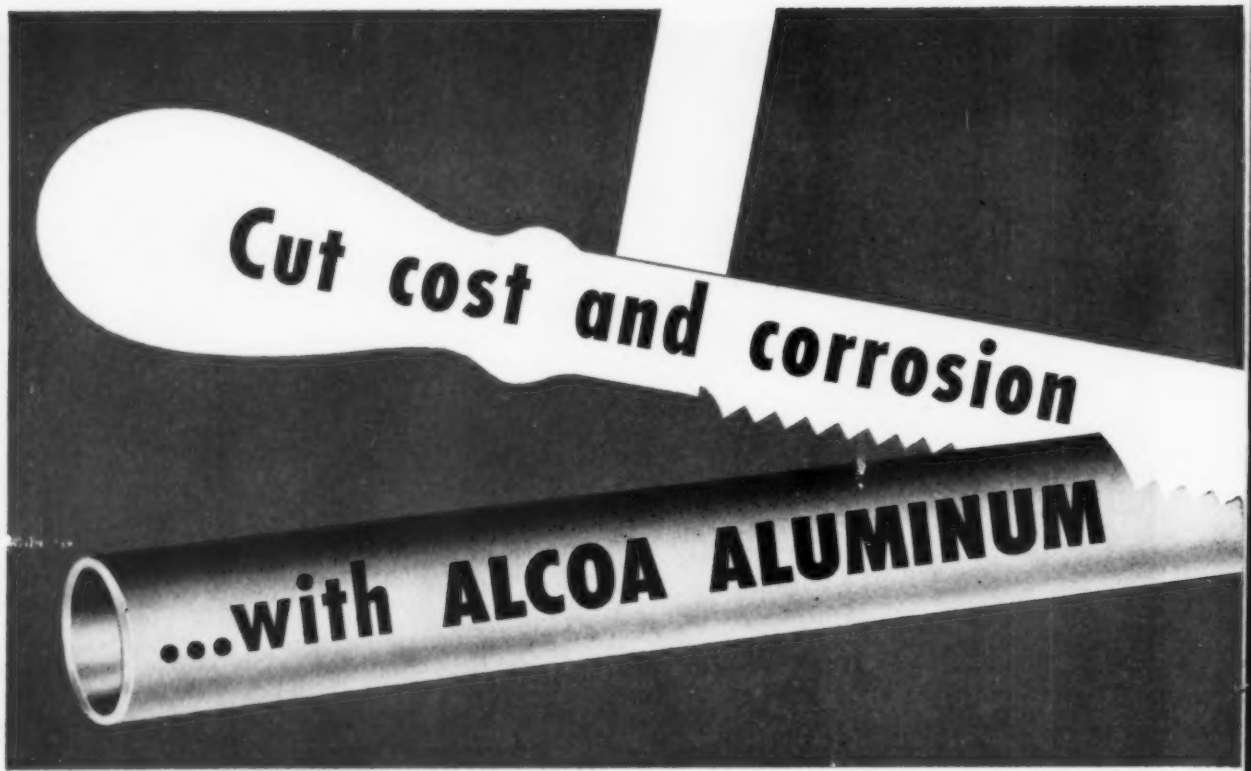
Few, if any, give a thought to the adventurous, risk-taking Cities Service men who devote their lives to making that casual command possible.

These men are trained in the sciences of geology and seismology . . . for the days of by-guess-and-by-gosh oil hunting are gone forever. Their record of "discovery wells" is high, but they dare not rest on their laurels. Americans have an insatiable thirst for oil, and the good things oil brings them.

That's why, as you read these words, a Cities Service exploratory crew is tramping over Canadian tundra . . . wading through Louisiana marshes . . . breathing the dust of southwestern deserts. Thanks to them, you can say "Fill 'er up!", confident that the answer will be a brisk "Yes, SIR!"—instead of "Sorry, Mister. That's all there is, there ain't no more."

CITIES SERVICE

Quality Petroleum Products



Having trouble with shipping these products?

It's time to consider tank cars of aluminum.

Acetaldehyde
Acetic Acid
Acetone
Acrylonitrile
Ammonia, Aqua
Ammoniacal Liquor
Ammonium Thioglycolate solution
Amyl Acetate
Benzaldehyde
Benzene (Benzol)
Benzyl Alcohol
Butyl Acetate
Butyl Alcohol
Butyric Acid
Butyric Anhydride
Carbon Bisulfide
Corn Syrup
Cottonseed Oil
Ethyl Alcohol
Ethyl Aniline
Ethylene Glycol
Ethylene Glycol Monoethyl Ether Acetate
Formaldehyde
Furfural
Glucose Syrup
Glycerin
Glyceryl Phosphate
Hydrogen Peroxide
Inks, Rotogravure
Lacquers
Methyl Alcohol
Naphtha
Nitric Acid (above 82% concen.)
Nitrogen fertilizer solutions
Nitro Paraffins
Oil
Castor
Coconut
Cottonseed
Fish
Pine
Soybean
Tall
Vegetable
Paraldehyde
Phenol
Phthalic Anhydride
Propionic Acid
Propionic Anhydride
Pyridine
Toluene
Toluidine
Turpentine
Urea Ammonia Liquor

. . . and aluminum tank cars *cost a third less* than stainless steel tank cars.

If you are shipping liquid ladings such as these, tank cars made of ALCOA Aluminum offer you very real cost-cutting advantages. Aluminum does not contaminate or discolor sensitive liquids—does not promote decomposition. Result: *no damage to ladings, better end products.* Aluminum is highly resistant to most corrosive ladings—requires far less maintenance than other metals.

Write today concerning the compatibility of your commodity in aluminum tank cars. Remember, Alcoa pioneered the aluminum tank car *years ago.* The accumulated knowledge of this development is yours for the asking.

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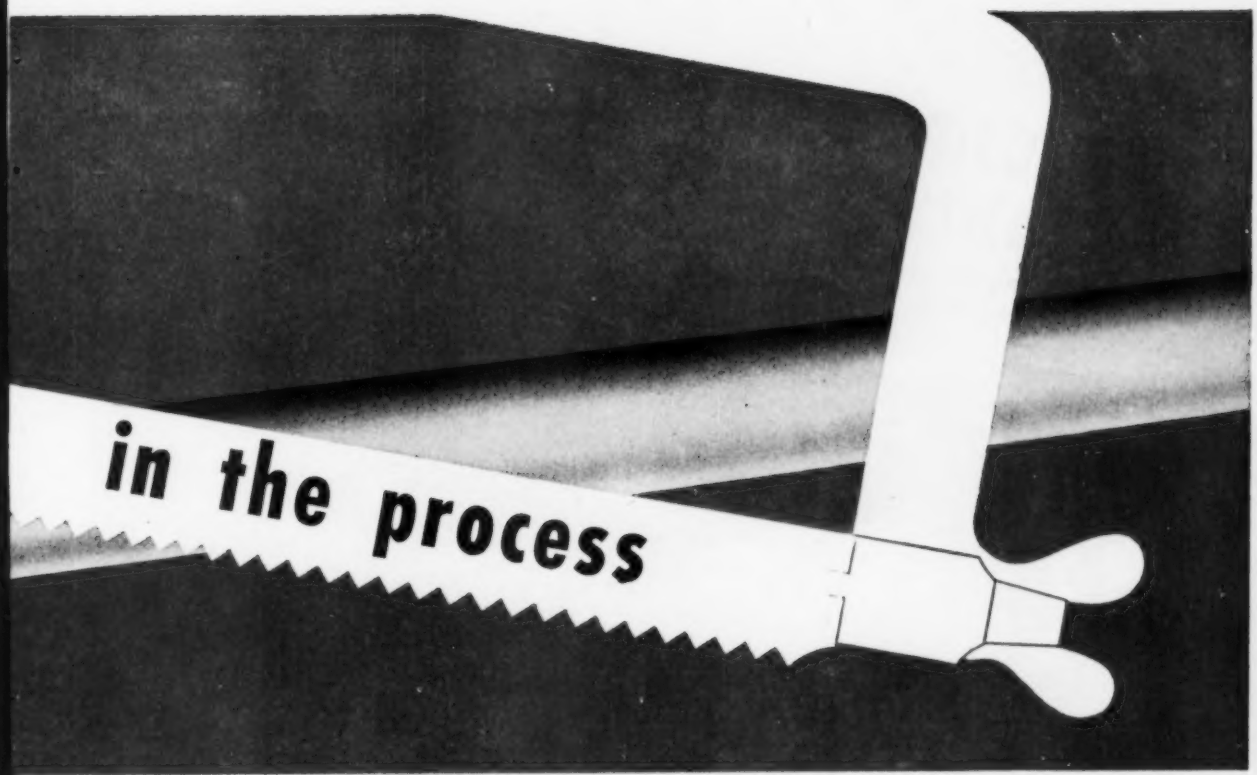

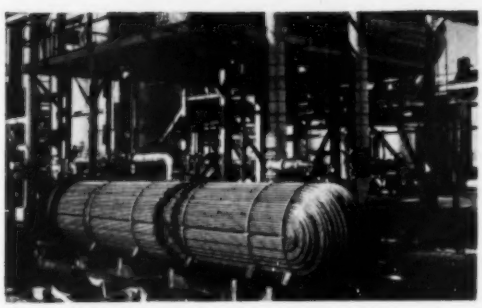

Griscom-Russel Re-boiler at El Paso Natural Gas Company, Farmington, New Mexico.

Got corrosion troubles?

So did El Paso Natural Gas Company's desulfurization plant near Kirtland, New Mexico, world's largest gas treating plant. Alloy steel tubing could not withstand the terrific acid conditions there. Result: *to minimize this trouble, condenser and heat exchanger tubing throughout the plant is being replaced by aluminum.*

Got cost troubles?

Alcoa Heat Exchanger Tubes cost 1/3 less than mild steel, 1/2 the price of Admiralty, 1/5 as much as stainless. Write for the booklet: "Alcoa Aluminum Heat Exchanger Tubes."

Looking for low-cost, corrosion-resistant pipe?

Alcoa Aluminum Pipe is the lowest cost corrosion-resistant metal pipe. Will not contaminate or discolor most chemicals. Does not cause sludge or gum in petroleum products. Ideal for railings, scaffolds, racks and other structural uses, especially in corrosive industrial atmospheres. Write for the booklet: "Alcoa Aluminum Pipe."

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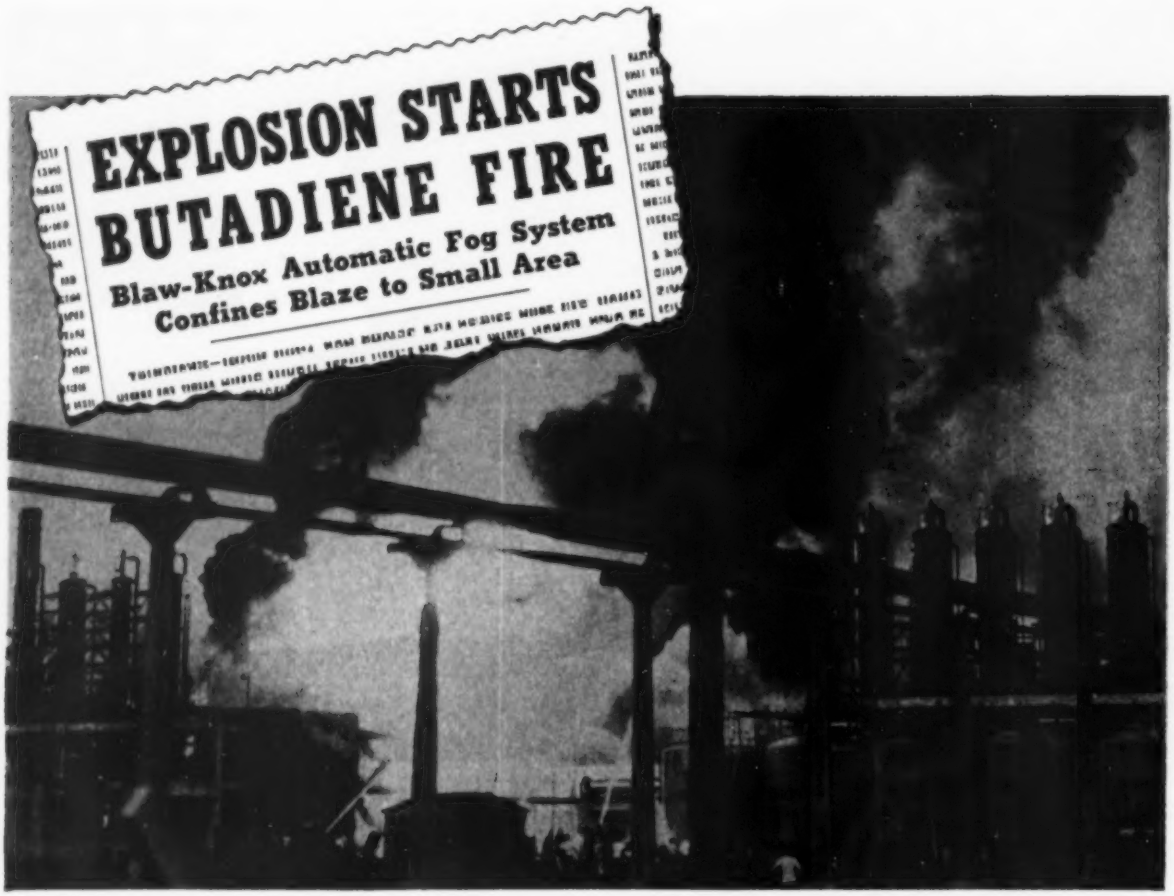

A serious fire, yes, but no "total loss"—thanks to the protection of adjacent equipment by smothering blankets of water from a

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Actuated by rate-of-rise thermostats, this system sounds an alarm and instantly throws a dense, quenching fog of water on the danger spot—either extinguishing or controlling the blaze while protecting adjacent equipment.

A Blaw-Knox System engineered for the fire hazards existing in or around your plant is a most effective weapon against fire's toll. Your insurance savings as they accrue applied to its cost—provide you with the utmost in fire protection plus a good financial investment . . . Glad to consult with you and submit an estimate without obligation.

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AUTOMATIC SPRINKLER DEPARTMENT
Pittsburgh 33, Pa.

Deluge Systems, Wet Pipe Systems, Dry Pipe Systems, Water Spray and Fog Systems, Rate-of-Rise Sprinkler Systems, and Foam and Carbon Dioxide Extinguisher Systems.

"LITTLE JOEY SPRINKLER"
Always on the Job

BLAW-KNOX **AUTOMATIC FIRE PROTECTION SYSTEMS**

and 31,000 gallons of propane. The plant's design provides for potential doubling of capacity simply by installation of additional compressors and a few minor equipment changes.

Douglas Oil Will Construct Cat Reformer at Bakersfield

Douglas Oil Company has entered the octane "race" with a report that an Atlantic catalytic reforming unit, with 2500-barrel-a-day charge capacity, will be completed at its Bakersfield, Calif., refinery before March, 1954. The plant has a crude charging capacity of about 8000 barrels a day.

Construction of the $500,000 project is scheduled to begin within 18 weeks with Ralph M. Parsons Company as contractor. Engineering work is under way.

Greek Government May Request Bids for Refinery Construction

An invitation to bid for construction by private companies of a refinery in Greece is expected to be issued by the Greek government soon, Washington industry sources have reported.

A representative of the Greek Embassy said he could not confirm the report but admitted his government "is considering" a bid invitation.

The Greek government is reported to be thinking in terms of a 25,000-barrel-a-day topping plant. Some doubts have been expressed as to the economic justification for a refinery there at this time, much less one that large.

Eastman Kodak Projects Plant For Polyethylene at Longview

A 20-million-pound plant for polyethylene at Longview, Texas, has been scheduled by Eastman Kodak Company, filling the gap in the American expansion plan set up by Imperial Chemical Industries, Ltd., British patent owner. The vacancy was created by the withdrawal of Firestone-Cities Service interests.

Kodak is well equipped for polyethylene at Longview, having placed a dual petrochemical plant in operation there over a year ago. One part uses the oxo process, the other cracks propane from natural gas into propylene and ethylene.

Contracts May Be Awarded Soon For New Canadian Refinery

Compagnie Financiere Belge Des Petroles (Petrofina) expects to award construction contracts before the end of 1953 for a refinery it plans to build in the province of Quebec, Canada. According to present plans, the refinery will be completed before the end of 1955. Until technical studies, now "well underway" are finished, details of the project will not be made available, a company official said.

Utah Chemical Plans to Build $18.8 Million Ammonia Plant

Plans to construct an $18.8 million ammonia plant in south central Utah have been announced by Utah Chemical Company, which has requested the National Production Administration to

Threads 4 sizes of pipe *fast* with 1 set of dies—*and it won't jam!*

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65R PIPE THREADER

This popular 65R has saved millions of hours of threading time, and no wonder—its one set of self-contained high-speed dies adjust to 1", 1¼", 1½" or 2" pipe size in 10 seconds! Mistake-proof self-centering workholder sets instantly! And lead screw won't jam on workholder, kicks out automatically at standard thread length! You can't match it for fast easy pipe threading —buy it at your Supply House.

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Work-Saver Pipe Tools

Starting a New Project?

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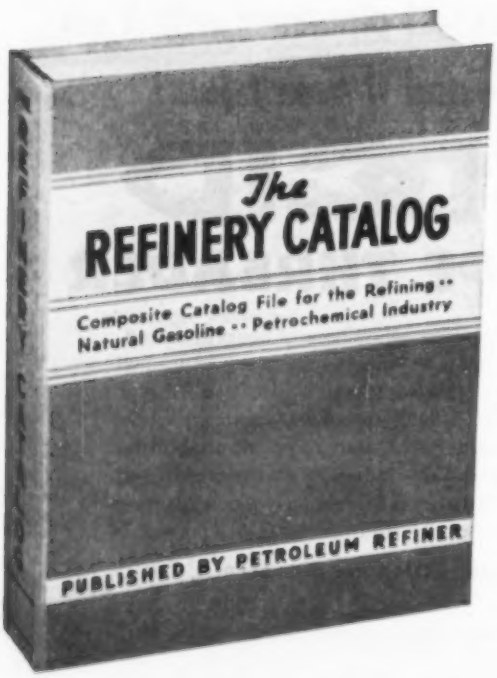
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Reach for your Refinery Catalog whenever you're planning a project. Turn to the easy-to-use index and you'll find that most of the known manufacturers have data filed in this universal equipment buyers guide. The 1953 edition carries catalog information on products and services offered by more than 300 manufacturers.

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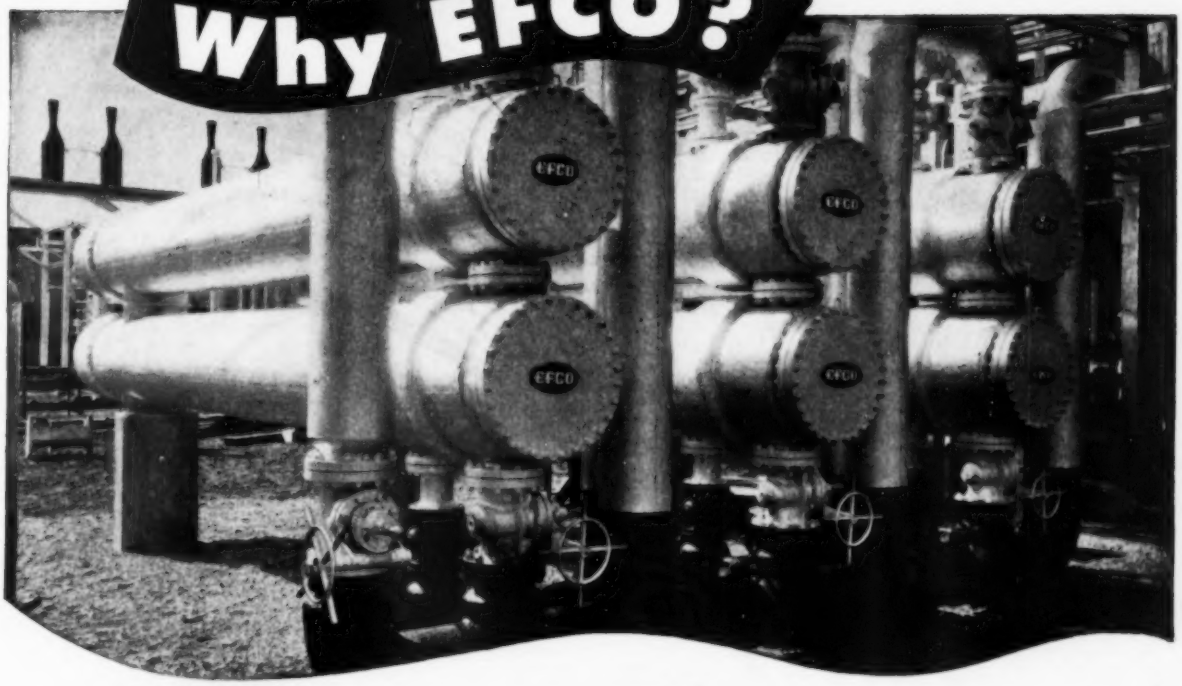
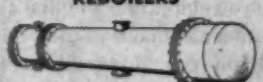


Performance is the answer!

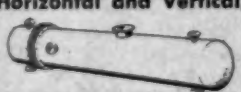
HEAT EXCHANGERS

REBOILERS

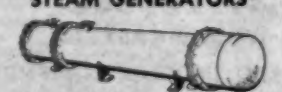


CONDENSERS

ATMOSPHERIC SECTIONS
(Horizontal and Vertical)



STEAM GENERATORS



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Talk over your heat transfer problems with an EFCO engineer. He will tell you about EFCO installations that have successfully solved problems similar to yours and explain how EFCO equipment will give you the performance you want.

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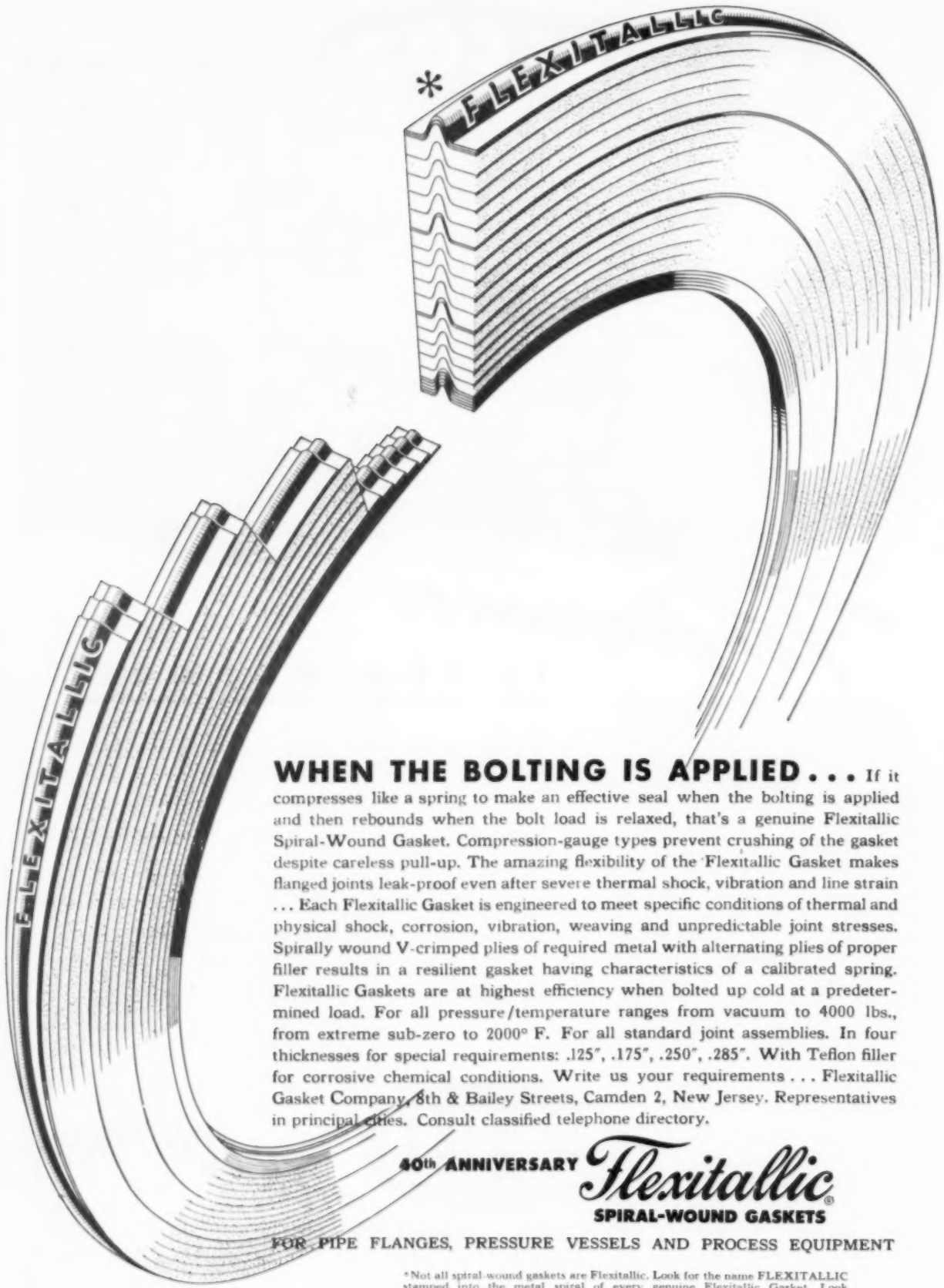

WHEN THE BOLTING IS APPLIED . . . If it compresses like a spring to make an effective seal when the bolting is applied and then rebounds when the bolt load is relaxed, that's a genuine Flexitallic Spiral-Wound Gasket. Compression-gauge types prevent crushing of the gasket despite careless pull-up. The amazing flexibility of the Flexitallic Gasket makes flanged joints leak-proof even after severe thermal shock, vibration and line strain . . . Each Flexitallic Gasket is engineered to meet specific conditions of thermal and physical shock, corrosion, vibration, weaving and unpredictable joint stresses. Spirally wound V-crimped plies of required metal with alternating plies of proper filler results in a resilient gasket having characteristics of a calibrated spring. Flexitallic Gaskets are at highest efficiency when bolted up cold at a predetermined load. For all pressure/temperature ranges from vacuum to 4000 lbs., from extreme sub-zero to 2000° F. For all standard joint assemblies. In four thicknesses for special requirements: .125", .175", .250", .285". With Teflon filler for corrosive chemical conditions. Write us your requirements . . . Flexitallic Gasket Company, 8th & Bailey Streets, Camden 2, New Jersey. Representatives in principal cities. Consult classified telephone directory.

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grant an amortization certificate for the project.

Site of the proopsed plant is reported to be either Sanpete Valley or near Nephl, along tracks of either the Denver & Rio Grande Western or Union Pacific.

The company's application to NPA states that Catalytic Construction Company, Philadelphia, subsidiary of Houdry Process Corporation, proposes to build the plant. The proopsed new plant would produce ammonia, nitric acid and ammonium nitrate through chemical union of natural gas with air and water, according to the NPA application. Daily production planned includes 278 tons of anhydrous ammonia, 475 tons of nitric acid and 587 tons of ammonium nitrate.

West German Refining Output Staying Ahead of Consumption

Capacity of the West German oil refining industry is rising faster than oil consumption, according to V.W.D., West German economic news agency.

The refining capacity of federal Germany increased from 5,700,000 tons (about 119,466 barrels a day) in 1952 to 7,300,000 tons (about 153,000 barrels a day) at the beginning of 1953. Consumption amounted to 5,800,000 tons (about 121,562 barrels a day) in 1952, and is expected to increase to 6,500,000 tons (about 136,233 barrels a day) this year. By 1956, the total oil refining capacity of West Germany is expected to reach 9,300,000 tons (about 194,918 barrels a day).

Continental Blacks to Build Oklahoma Carbon Black Plant

A $2,750,000 plant to manufacture 40 million pounds of high abrasion black from oil will be built at Ponca City, Okla., by Continental Blacks, Inc., a newly formed organization. Continental Oil Company and The Shamrock Oil and Gas Corporation will be joint owners of the new enterprise.

Construction of the carbon black plant, which will receive its raw materials from Conoco's refinery at Ponca City, will start this summer. It is expected to be completed by mid-1954.

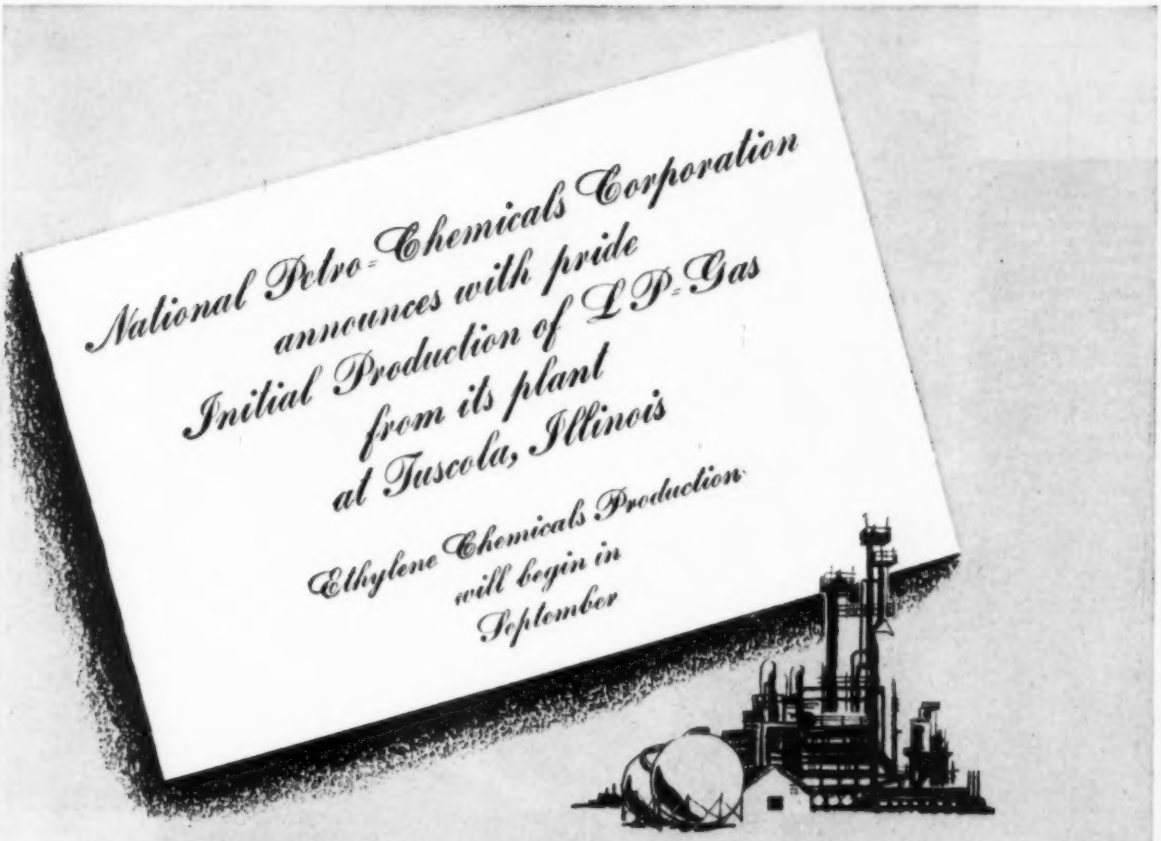
CONSTRUCTION **BOXSCORE**: Refineries and Other Plants

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
EAST									
Allied Chemical	Hopewell, Va.	Syn. Nitrogen	†50,000 tons yr.	$12.5 million					
Allied Chem. & Dye	Buffalo, N.Y.	Aromatic Fac.		$6,940,000	PAD Certified				
Ashland O&R	Tonawanda, N. Y.	Expansion	†25,000 bbls.	$4,000,000	Completing		U.O.P.	McKee	McKee
Ashland O&R	Tonawanda, N. Y.	Auxiliaries		$3,500,000	Completing			Catalytic	Catalytic
Atlantic Refining Co.	Philadelphia, Pa.	Detergent Mfg.		$1.5 million	Under Constr.			Atlantic	Ferguson
Atlantic Refining Co.	Philadelphia, Pa.	Cat. Reform.	11,000 bbls.	$4 million	Under Constr.	1953	Atlantic	Badger Div.	Badger Div.
Atlantic Refining	Philadelphia, Pa.	Two stage pipe still, Cat; Alky; Poly Units	50,000 bbls.	$5.6 million	Under Constr.	1953			Badger Div.
Atlantic Refining	Philadelphia, Pa.	Orthoflow Cat. Cracking	45,000 bbls.		Spring Constr.	1953		Kellogg	Kellogg
Atlantic Refining	Philadelphia, Pa.	Syn. Ammonia	100 tons		Under Constr.	Completing	Hydrocarbon	Hydrocarbon	Hydrocarbon
*Atlantic Refining	Philadelphia	Two Stage Crude Dist.	45,000 bbls.		Under Constr.			Foster Wheeler	Foster Wheeler
Bureau of Mines	Morgantown, W. Va.	Experiment Sta.	12 tons coal	$2.6 million	Under Constr.	Mid 1954		Bureau	Southeastern Constr. Co.
California Oil	Barber, N.J.	Cat. Poly.	675 bbls.		Under Constr.	Completing	California Research Corp.	Hydrocarbon	Hydrocarbon
California Oil Co.	Barber, N.J.	Revamp Thermal Reformer to Cat. Reformer			Design	1954	U.O.P.		
Delta Refining Co.	Memphis, Tenn.	Increase Cap.	†2,000 bbls.		Completing				
Dewey & Almy Chemical Co.	Cambridge, Mass.	Synthetic Rubber Addition		$404,000					
E. I. du Pont de Nemours	Kinston, N.C.	Dacron Polyester Fiber		$3,000,000	Planning	1954			
Esso Standard	Everett, Mass.	Fluid Cat. Crk.	†18,500 bbls.		Under Constr.	3rd Qtr., 1953		S.O.D.	Foster Wheeler
*Esso Standard	Everett, Mass.	Propane Plt.			Announced	2nd Qtr., 1954		S.O.D.	
Esso Standard	Linden, N.J.	Crude Pipe Still	60,000 bbls.		Announced	3rd Qtr., 1954		S.O.D., Kellogg	Kellogg
Esso Standard	Bayonne, N.J.	Wax Pipe Still	3,500 bbls.		Under Constr.	End 1953		S.O.D., Fluor	Fluor
*Esso Standard	Linden, N.J.	Hydrofining	21,500 bbls.		Announced	4th Qtr., 1954		S.O.D., Braun	Braun
		Hydrofiner	20,000 bbls.			Mid 1954			
Ethyl	Edgemor, Del.	Tetraethyl Lead		$184,125	Completed				
Gulf	Philadelphia	Crude; Atoms. & Vacuum Unit	125,000 bbls.		Under Constr.	Fall, 1953		Foster Wheeler	Foster Wheeler
Gulf Oil Corp.	Philadelphia	Sulfur Recovery		$1.1 million	DPA Certified				
Gulf	Philadelphia	Gasoline Sweet	40,000 bbls.		Under Constr.	Fall, 1953		Gulf	Gulf
Gulf	Philadelphia	Cat. Poly.	10,000 bbls.		Under Constr.	Early, 1954		Bechtel	Kellogg
Gulf	Philadelphia	Cat. Cracker	63,000 bbls.		Under Constr.	Fall, 1953		Kellogg	Kellogg
Hercules Powder	Gibbstown, N.J.	Petrochemicals		$8 million	Under Constr.	Jan., 1954		Kellogg	Kellogg
Mathieson Hydrocarbon Chemical	Brandenburg, Ky.	Chemical Plt.		$17 million	Under Constr.			Badger Div.	Badger Div.
M. F. A. Oil	Memphis, Tenn.	Cat. Crk. & Aux.	2,200 bbls.	$1.7 million	Completing		So-Vac.	Koch	Koch
Monsanto	Springfield, Mass.	Polyvinyl chloride resin		$1.2 million	Announced				
*Pan American Petroleum & Transport	City unknown	Refinery	25,000 bbls.	$20,000,000	Options taken				
*Pennsylvania Industrial Chemical Corp.	Jefferson, Pa.	Petrochem. Plt.			Under Constr.	Summer 1954			
*Sinclair Refining	Marcus Hook, Pa.	Cat. Reforming	16,000 bbls.	$14,000,000	Projected	Summer, 1954			Braun
		LPG Expan.	900 bbls.	$1,000,000	Under Constr.	End, 1953			
Socony-Vacuum	Paulsboro, N.J.	Alkylation Exp.			Under Constr.	Dec., 1953		Soc-Vac.	Soc-Vac.
Socony-Vacuum	Paulsboro, N.J.	TCR Catalyst			Under Constr.	Sept., 1953	Soc-Vac	Bechtel	Bechtel
Sun Oil Co.	Marcus Hook, Pa.	Aromatics Rec., Houdriformer	10,000 bbls.	$8.7 million	Under Constr.	Late Summer, 1953	Houdry & U.O.P.	Sun	Sun
*Texas Company	Westville, N. J.	Cat. Reforming	11,000 bbls.		Under Constr.	4th Qtr., 1954			
		Alkylation Fac.	1,750 bbls.		Under Constr.	4th Qtr., 1954			
Texas Company	Westville, N.J.	Crude Desalt.	60,000 bbls.		Completed			Texas Co.	
*Union Carbide & Carbon Corp	Leaksville, N.C.	Dynel Fiber Plt.		$30,000,000	Planning	1955		Staff	
United Refining Co.	Warren, Pa.	Cat. Reform. Plt	2,500 bbls.		Under Constr.	Aug., 1953	Atlantic	Blaw-Knox	Blaw-Knox
United Refining Co.	Warren, Pa.	Lab.			Under Constr.				
*United Refining	Warren, Pa.	Treating Fac.	750 bbls.		Under Constr.	Aug., 1953		Blaw-Knox	Blaw-Knox
MID-CONTINENT									
Allied Chemical & Dye Corp.	South Point, O.	Synthetic Nitrogen	50,000 tons yr.	$12.5 million	Design				
*Allied Chemical & Dye	Cleveland, Ohio	Chemical Plt.		$2,000,000	Under Constr.	1954		Dorr. Co.	M-C & S.
Amerada Pet. Corp.	Williston, Basin, N. D.	Natural Gasoline Plt.		$10 million	Planning				
Anderson-Prichard Oil Corp.	Arkansas City, Kans.	Expansion	14,000 bbls.		Planning				
Ashland O&R	Canton, Ohio	Tankage, Misc.		$500,000	Under Constr.	Late 1953		Staff	Staff

CONSTRUCTION **BOXSCORE**: Refineries and Other Plants

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Aurora Gasoline	Detroit, Mich.	Basic Refining		$400,000	Announced				
Aurora Gasoline Co.	Elsie, Mich.	UOP Platformer	1,500 bbls.		Completing		U.O.P.		Procon
Ben Franklin Refg.	Ardmore, Okla.	Cat. Crker., Poly	†10,000 bbls.	$2 million	Completing		U.O.P.	U.O.P.	Staff
Central Petroleum Co.	Coyle ,Okla.	Gasoline Plt.			Authorized				
Champlin Refining Co.	Enid, Okla.	Cat. Reformer			Considering				
Cities Service Oil Co.	Chicago, Ill.	Grease Making	8.5 million lbs.		Completed				
Cities Service Oil Co. (Del.)	E. Chicago, Ind.	Topping Unit, Fluid Hydro-former	30,000 bbls. 12,780 bbls.	$2 million $4 million	Under Constr. Under Constr.	1954 1954		McKee Kellogg	McKee Kellogg
Consumers Coop.	Phillipsburg, Kans.	Dist. Expan.	†4,000 bbls.		Completing			Ref. Eng.	Ref. Eng.
*Continental Blacks, Inc.	Ponca City, Okla.	Carbon Black Plt.	40,000,000 lbs./yr.	$2,750,000	Under Constr.	Mid 1954			
Continental Oil	Ponca City, Okla.	Expansion	None	$7.5 million	Under Constr.	1954	Continental	Staff	Staff
*Continental Oil Co.	Ponca City, Okla.	Additive Plt.			Under Constr.	Spring, 1954			
*Cooperative Farm Chemicals Assn.	Lawrence, Kans.				Under Constr.	August, 1954	Texaco Dev., Casale	Foster Wheeler	Foster Wheeler
Cooperative Refinery Assoc.	Phillipsburg, Kans.	Increase Cap. Vacuum Unit	8,000 bbls., 3,500 bbls.	$1,050,000	Completing			Staff & U.O.P.	Staff
*Deere & Company	Pryor, Okla.	Ammonia Plt. Urea Plt.	180 tons 270 tons		Under Constr.	Spring, 1954	Texaco Dev.	Foster Wheeler Foster Wheeler	Foster Wheeler Foster Wheeler
Detroit Chem. Wks.	Detroit, Mich.	Sulfuric Acid		$950,000	PAD Certified				
Dow Chemical	Midland, Mich.	2nd Hypersorp-tion Unit			Under Constr.		Union Oil (Calif.)	Foster Wheeler	Foster Wheeler
Dow Chemical	Ludington, Mich.	Bromine for TEL	2 million lbs. yr.	$433,500	Under Constr.				
Dow Chemical	Midland, Mich	Ethylene Di-bromide		$370,000	Under Constr.				
*E. I. DuPont de Nemours	Circleville, Ohio	Mylar Polyester Plt.		$10,000,000	Under Constr.	Early, 1955			
El Dorado Refining	Eldorado, Kans.	Expansion	†4,000 bbls.	$3 million	Completed		U.O.P.	Ref. Eng.	Ref. Eng.
Globe Oil & Refg.	Lemont, Ill.	Alkylation Unit, Cat. Crker.	5,000 bbls. 10,000 bbls.	$4 million	Under Constr. Under Constr.	April, 1954 April, 1954	Phillips U.O.P.	Koch U.O.P.	Staff Staff
*Grace Chemical	Memphis, Tenn	Ammonia Plt., & Urea	250 tons		Under Constr.	Summer, 1954	Texaco Dev., Casale & Pechiney	Foster Wheeler	Foster Wheeler
Great Northern	St. Paul, Minn.	Crude Topping	20,000 bbls.						
Great Northern Oil	St. Paul	Cat. Crk.	7,620 bbls.	$26 million	Certified DPA				
Great Northern	St. Paul	Cat. Reformer	6,000 bbls.						
Great Northern	St. Paul	Cat. Poly.	680 bbls.						
Gulf Oil	Cincinnati, Ohio	Canning Plt.			Announced				
Hooker Electro-Chemical Co.	Montague, Mich.	Chlorine Caustic		$12 million	Under Constr.	4th Qtr., 1953		Staff	Ferguson
Leonard Refineries	Alma, Mich.	Expand. Crk. Capacity	†4,000 bbls.	$500,000	Completed		Houdry	Cat. Constr.	Cat. Constr.
*Leonard Refineries	Alma, Mich.	Vacuum Unit	4,500 bbls.		Under Constr.	Aug., 1953	Amer. Dev.	Ref. Eng.	Ref. Eng.,
		Treating Unit	6,000 bbls.		Under Constr.	Aug., 1953		Amer. Dev.	Staff
		PropaneTrtg.	200 bbls.		Under Constr.	Aug., 1953			
Lion Oil	El Dorado, Ark.	Cat. Crk. Unit	5,000 bbls.	$5 million	Under Constr.	Late 1953	Kellogg	Lummus	Lummus
Lion Oil	El Dorado, Ark.	Alkylation Plt.	1,150 bbls.		Under Constr.	Late 1953	Texaco Dev.		
Michigan Chem	St. Louis, Mo.	Sulfuric Acid		$81,581	PAD Certified				
*Mid-Continent Petroleum	W. Tulsa, Okla.	Cat. Reformer & Avgas	7,500 bbls.	$2,738,322	Engineering	Aug., 1954			
	W. Tulsa, Okla.	Alkylation Exp.	500 bbls.	$433,428	Planning				
Mid-Continent Petroleum	West Tulsa, Okla.	Cat. Crker, Exp., Gaso. Debutan-izer	21,000 bbls. 10,000 bbls.	$536,015	Under Constr. Under Constr.	Completed Completed		Kellogg Kellogg	Staff Staff
Mid-West Refineries, Inc.	Alma, Mich.	Gasoline	1,400 bbls.		Completed			Staff	Staff
Mid-West Refineries, Inc.	Alma, Mich.	Increase Ther-mal Cracking Capacity	3,600 bbls.	$348,000	Completed		U.O.P.	U.O.P.	Staff
Midland Coop. Wholesale	Cushing, Okla.	Capacity Exp. & Cat. Poly.	10,500 bbls.	$3 million	Complete		U.O.P.	UOP & Ref. Engineers	Refinery Engineers
Minnesota Mining	Copley Twp., Ohio	Sulfuric Acid Fac.		$2.1 million	Under Constr.				
*Mississippi Chemical Corp.	Yazoo City, Miss.	Increase Cap. of Ammonia Plt.	†60 tons	$2,000,000	Under Constr.	Late 1953			Girdler
*Mississippi River Fuel Corp.	St. Louis, Mo.	Petrochem. Fac.			Proposed				
*Missouri Farmers Association	Joplin, Mo.	Fertilizer Plt.	220 tons	$3,500,000	Under Constr.	1954		Dorr Co.	M-C & S.
Monsanto Chemical	Addyston, Ohio	Styrene Plastics			Plan				
National Coopera-tive Ref. Assoc.	McPherson, Kans.	Cat. Crker, Cat. Polymerization	4,500 bbls., 300 bbls.	$2,400,000	Completing		U.O.P.	U.O.P. & Ref. Eng.	Ref. Eng.
National Coopera-tive Ref. Assoc.	McPherson, Kans.	Coker	10,000 bbls.	$1,200,000	Under Constr.	Oct., 1953	U.O.P. doing Process Specif.	Ref. Eng.	Ref. Eng.
*National Petro-chemical	Tuscola, Ill.	Chemical Plt.						Foster Wheeler	Foster Wheeler
Northwestern Refining	St. Paul Park, Minn.	Topping	30,000 bbls.	$2 million	Completing				
Ohio Oil Company	Robinson, Ill.	Houdriforming	8,000 bbls.		Under Constr.	Late 1953	Houdry	Houdry	Cat. Constr.
*Ohio Oil	Robinson, Ohio	Cat. Cracker Expansion	18,000 bbls.		Planning	Jan., 1954		Staff	Staff
		Cat. Poly Expan	4,800 bbls.		Planning	Jan., 1954		Staff	Staff
		Alkylation Unit	1,500 bbls.	$1,800,000	Contracted				
Oklahoma Refg. Co.	Seminole, Okla.	Refinery	200 bbls.	$40,000					
Old Dutch Refining	Muskegon, Mich.	Aromatic Fac.	150 B. 370 T.	$515,130	Completed				
Pana Refining Co.	Pana, Ill.	Modernization	†1,000 bbls.	$900,000					
Pana Refining	Pana, Ill.	Girbotol Unit			Under Constr.				Parker
*Pennsylvania Salt	Wyondotte, Mich.	Ammonia Plt.	220 tons		Under Constr.			Foster Wheeler	Foster Wheeler
Petroleum Specialties	Flat Rock, Mich.	Cat. Cracker	3,000 bbls.	$2 million	Planning				
Petroleum Specialties	Flat Rock, Mich.	Visbreaker	2,500 bbls.		Under Constr.	1953			
Pure Oil	Toledo, Ohio	Alkylation Unit (Sulfuric Acid)		$2.5 million	DPA Ok'd Planning				
Pure Oil	Toledo, Ohio	Modernization	30,000 bbls.		Under Constr.	1953		Kellogg	Kellogg
Pure Oil	Toledo, Ohio	Orthoflow Cat.	15,000 bbls.		Under Constr.	1953		Kellogg	Kellogg
*Queen City Refinery, Inc.	Dickinson, N. Dak.	Refinery			Site Purchased				
R. J. Oil & Refining	Pana, Ill.	Platform. Unit	600 bbls.		Engineering		U.O.P.	Procon	Procon
Roosevelt O&R	Mt. Pleasant	Platformer	1,750 bbls.		Completed		U.O.P.	U.O.P.	Procon
Shallow Water Refining	Shallow Water, Kans.	Cat. Cracker & Auxiliaries	3,000 bbls. (Gas Oil Charge to Cat. Cracker)	$1,700,000	Planning	Late, 1954			
Shell Oil	Wood River, Ill.	Expansion and Improvement	†50,000 bbls.	$42.5 million	Under Constr.	Late 1954		Shell	Foster Wheeler, Fluor & McKee
Shell Oil Company	Wood River, Ill.	Platforming Unit	16,000 bbls.		Planning	End, 1953	Procon	Procon	Procon
Shell Oil Co.	Elk City, Okla.	Cap. Increase	†70 Mmcf.						

• TABLE CONTINUED ON PAGE 197



A NEW SUPPLY of liquefied petroleum gas has become available through the opening of National Petro-Chemicals Corporation's giant natural gas stripping plant at Tuscola, Illinois. This is the first step in the completion of a $44 million project which will include the largest ethylene plant in the world. The ethylene will be used to make synthetic ethyl alcohol, ethyl chloride, and later the wonder plastic, polyethylene.

Located on the Baltimore & Ohio Railroad, at the junction of the natural gas pipe lines of the Panhandle Eastern Pipe Line Company and the Trunkline Gas Company, the plant will process 400 million cubic feet per day of natural gas. Daily production of propane, butane, isobutane, and natural gasoline will total 450,000 gallons, and will be distributed by the Phillips Petroleum Company, makers of "Philgas." Ethane recovery for the production of ethylene will amount to 10 million cubic feet per day.

Off-season storage for propane will be provided by a 6 million gallon underground cavern which will supplement conventional working storage consisting of 35 horizontal steel tanks each with a capacity of 50,000 gallons. Butane, isobutane, and natural gasoline will be stored in 4 Hortonspheres with a total capacity of 900,000 gallons.

Tank car shipments of LP-Gas will be handled at a 40-spot loading rack designed to load a day's production in 8 hours. Tank trucks will load 24 hours per day at 3 islands equipped with 6 propane spots and 3 spots each for butane, isobutane, natural gasoline.

Latest procedures in quality control and modern laboratory facilities have been incorporated to guarantee industry products that perform as specified.

This new project has everything for the long-term contract user of bulk petro-chemicals. The future belongs to petro-chemicals. Why not let "PETRO" help you plan today for a better tomorrow!

NATIONAL PETRO-CHEMICALS

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A joint enterprise of National Distillers Products Corporation and Panhandle Eastern Pipeline Company

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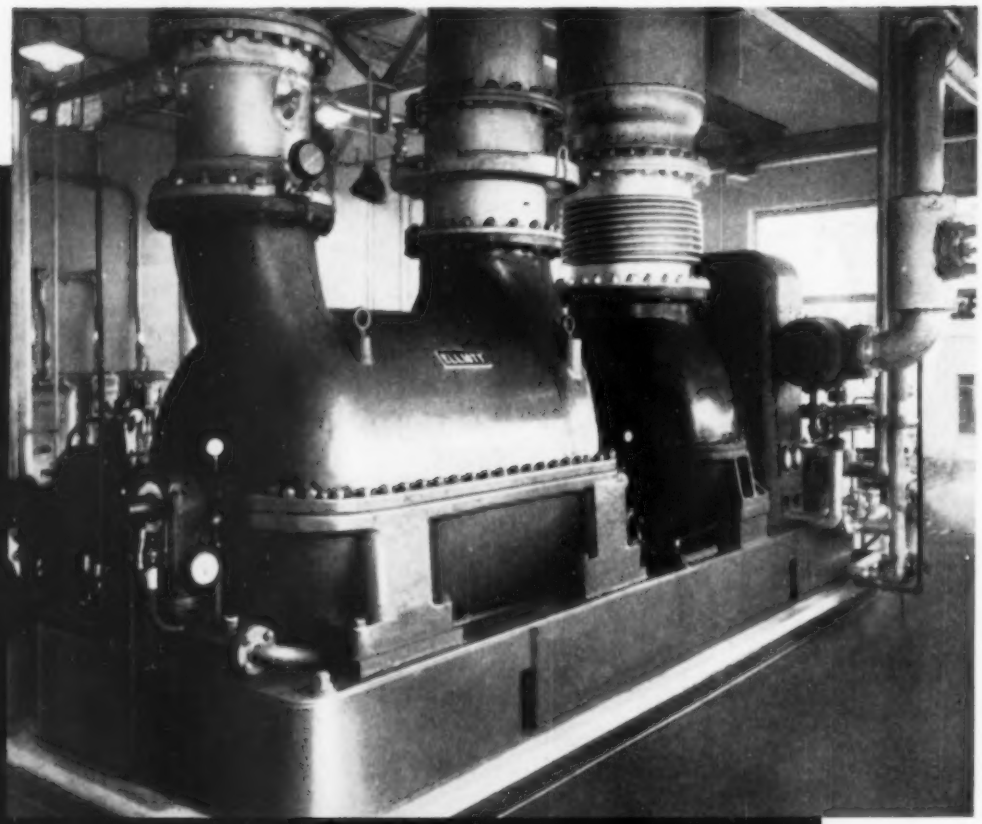


Elliott turbine-driven blower serving cat cracker at the modernized McMurrey Refinery, Tyler, Texas. The blower is rated 16,750 inlet cfm with a 25.5 psi pressure rise. The Elliott 1760-hp condensing steam turbine is direct-connected, operating at 6030 rpm.

FOR THE LONG RUN...

ELLIOTT *Centrifugal* BLOWERS

● Meeting the high reliability requirements of refinery service, Elliott blowers and compressors have aided in establishing several outstanding records for continuous performance of a refinery. They are recognized for their dependability and high availability. Since Elliott can furnish the driver as well as the blower or compressor, unified responsibility is a further advantage. The centrifugal air blower pictured above is typical of the many Elliott blowers now serving the oil industry. Similar blowers are handling hydro-carbon gases in the same refineries and are proving to be more reliable and less costly to maintain than displacement type compressors previously used for this service.

For details, contact your local Elliott representative or write Elliott Company, Jeannette, Pa.

ELLIOTT Company

CENTRIFUGAL BLOWER DEPARTMENT

P3-5

CONSTRUCTION **BOXSCORE**: Refineries and Other Plants

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Signal Oil Co.	Tioga, N.D.	Nat. Gaso. Plt.	40 Mmcf.	$15,000,000	Projected	Fall, 1954		Pritchard	Pritchard
*Sinclair Refining	Hartford, Ill.	Asphalt Fac.		$600,000	Design	Spring, 1954			
*Sinclair Refining	E. Chicago, Ind.	Barrel House Fac.		$2,700,000	Design	Summer, 1954			
*Sinclair Refining	E. Chicago, Ind.	Power Plt. Addi.		$570,000	Design	Summer, 1954			
Skelly Oil	Velma, Okla.	Booster Station			Planned				
Socony-Vacuum	Trenton, Mich.	Cat. Poly. Unit			Design	Dec., 1953	Calif. Res.	Badger	Badger
Socony-Vacuum	Augusta, Kans.	T C R		$3 million	Design	Jan., 1954	Soc-Vac.	Bechtel	Bechtel
Socony-Vacuum	E. St. Louis, Ill.	Alky. Expan.	775 bbls.	$260,000	Design	June, 1954		Soc-Vac	Soc-Vac
Socony-Vacuum	E. St. Louis, Ill.	TCC	15,000 bbls.		Design	June, 1954	Soc-Vac.	Lummus	Lummus
Socony-Vacuum	E. St. Louis, Ill.	Cat. Poly.			Design	June, 1954		Lummus	Lummus
*Sohio Petroleum Co.	Elmore City, Okla.	Gasoline Plt.	10 Mmcf.		Under Constr.	Aug., 1953		Born Eng.	Born Eng.
Spencer Chemical Company	Vicksburg, Miss.	Petrochemical	200 tons	$14 million	Under Constr.	Late 1953	Texaco Dev.	Foster Wheeler, Staff	Foster Wheeler, Quaker
Standard-Indiana	Wood River, Ill.	Fluid Hydro-former	9,000 bbls.		Design	Late 1954			
Standard-Ind.	Wood River, Ill.	Alcohols Prod	30,000 lbs.	$2.6 million	Under Constr.	3rd Qtr., 1953			
Standard (Indiana)	Mandan, N.D.	New Crude Ref	30,000 bbls.		Under Constr.	3rd Qtr., 1954			Lummus
Standard (Indiana)	Whiting, Ind.	Hydroformer	24,000 bbls.		Design	Late 1954			
*Standard (Indiana)	Whiting, Ind.	Para-Xylene	38,400 bbls.		Design	Late 1954			
Standard (Indiana)	Wood River, Ill.	Cumene Plt.	630 bbls.		Completing				
Standard Oil of N.D.	Grand Forks, N. Dakota	Refinery	2,000-2,500 bbls.		Planning				
*Standard (Ohio)	Lima, Ohio	Operating Units for Cat. Ref.		$4,000,000	Under Constr.				Procon
The Standard Oil Co. (Ohio)	Lima, Ohio	Platformer	12,000 bbls.	$8 million	Design	May, 1954		U.O.P.	Procon
Standard (Ohio)	Toledo, Ohio	Alkylation Unit	1,500 bbls.	$3 million	Completing			McKee	McKee
*Standard (Ohio)	Cleveland, Ohio	Crude Topping	7,000 bbls.	$4,200,000	Design				
		Cracker, Poly	18,000 bbls.						
		Cat. Reforming	3,000 bbls.	$8.5 million	Engineering	Mid 1954			
Stanolind Oil & Gas Company	Tulsa, Okla.	Research Center			Completing			Shreve, Lamb & Harmon	Manhattan
Sterling Oil of Okla., Inc.	Garfield Co., Okla.	Gaso. Ext. Plt.			Planning				
Sterling Oil of Okla.	Oklahoma Co., Okla.	Gaso. Ext. Plt.			Planning				
Sun Oil	Toledo, Ohio	Platform Unit	10,000 bbls.	$7.2 million	Design	Fall, 1953	U.O.P.	Procon-Sun	Procon-Catalytic
*Sun Oil Co.	Toledo, Ohio	Gas Plt.			Projected	Indefinite		Catalytic	Catalytic
Sunray Oil	Duncan, Okla.	Alkylation Fac.	2,400 bbls.	$1.7 million	Completing		U.O.P.	Ref. Eng.	Ref. Eng.
*Sunray Oil	Duncan, Okla.	Coking Unit	9,000 bbls.		Planned				
Texas Natural Gasoline	Tulsa, Okla.	Gasoline, Propane, Butane			Announced				
The Texas Co.	Lockport, Ill.	Lube Oil Plt.	3,485 bbls.	$17.6 million	Certified DPA				
The Texas Co.	Lockport, Ill.	Crude Expan.	125,000 bbls.	$15 million	Not Certified				
*Warren Petroleum	Antioch, Okla.	Nat. Gaso. Plt.		$654,000	DPA Certified				
*Warren Petroleum	Panther Creek, Okla.	Propane, Butane, Nat. Gaso. Fac.		$609,000	DPA Certified				
White Eagle Petroleum	Augusta, Kans.	Therm. Cat. Reform.			Projected				
Williston Refining	N. Dakota	Complete Refg.	10,000 bbls.	$5 million	Announced		U.O.P.	Ref. Eng.	Ref. Eng.
Wood River Oil Refining	Calumet, Ill.	Crude Topping, Crk.; Poly.	15,000 bbls. 6,800/600 bbls.	$1 million	Design				
SOUTHWEST									
Acadia Corp.	Shreveport, La.	Motor Gas Unit		$2.9 million	Design				
*Allied Chemical & Dye	Baton Rouge, La.	Sulfuric Acid Plt.			Under Constr.	End 1953			
Allied Chemical & Dye (Solvay)	Orange, Texas	Petrochemicals Unit		$5 million	Under Constr.	Spring, 1954			
American Cyanamid Company	New Orleans, La.	Petrochem. Plt.		$30 million	Under Constr.	1954		Chemico	Chemico
American Liberty Oil Company	Mt. Pleasant, Texas	T. C. C. Gas Fract. Feed Prep. Gas Con., Poly. Revamp	5,120 bbls.	$2.7 million	Under Constr.	Late 1953	Soc-Vac.	Fluor	Fluor
American Oil Co.	Texas City, Tex	Cat. Crker.			Under Constr.	1953			
American Petro-Chemical Corp.	Lake Charles, La.	Polyethylene Plt.	$15-20 million		Planned				
American Republics Corp.	Hardin Co., Texas	Deisobutanizer, Propanizer	500 bbls.	$250,000	Completed			Gas Plt. Constr.	Gas Plt. Constr.
Anchor Gasoline Corp.	North Tepetate, La.	Gasoline Plt.	360 bbls.		Completing				
Arkansas Fuel Oil Company	Carthage, Texas	Increase Butane & Propane Rec.	100 Mmcf		Completing			Staff	
Arkansas Fuel Oil Company	Jefferson, Texas	Increased LPG Rec.	31 Mmcf		Under Constr.	1953		Staff	
Aromatics Refining	Baton Rouge, La.	Aromatics Fac.		$11.6 million	Design				
*Atlantic Refining Co.	Atreco, Texas	Cat. Reforming	7,500 bbls.		Contracted				Ferguson
Barnsdall Oil Co., Op.	Scurry Co., Tex.	Natl. Gaso. Plt.	50,000 mcf gas	$6.5 million	Considering				
H. W. Bass & Sons, Inc.	Live Oak Co., Texas	Nat.Gas.		$3 million	DPA Certified				
J. R. Butler Interests	Howard County Texas	Natural Gasoline Plt.			Planned				
Carbide & Carbon Chemicals	Texas City, Tex	Acetylene Plt.			Under Constr.	1953			
Carbide & Carbon Chemicals	Texas City, Tex	Poly. Resins	140,000 lbs.		Under Constr.	1953			
Carbide & Carbon Chemicals	Seadrift, Texas	Polyethylene & Ethylene Oxide	140,000 lbs.	$43 million	Under Constr.	April, 1954		Brown & Root	Brown & Root
Celanese Corp. of America	Pampa, Texas	Vinyl Acetate Facl.			Completed				
Cities Service	Lake Charles, La.	Fluid Hydro-former	17,250 bbls.	$7 million	Engineering	1954		Kellogg	Kellogg
Cities Service Oil	Pampa, Texas	Gasoline Expan.		$222,139	Certified DPA				Parsons
Cities Service Refg.	Lake Charles	Hydro. Feed Prep.	44,450 bbls.	$2 million	Engineering	1954		Kellogg	Kellogg
Cities Service Refg.	Lake Charles	Vacuum	26,750 bbls.	$4 million	Engineering	1954		Kellogg	Kellogg
Cities Service Oil Co.	Crockett Co., Texas	Nat. Gas		$2.4 million	DPA Certified				
Col-Tex Refining Co.	Colorado City, Texas	Platforming Unit	1,500 bbls.	$933,000	Under Constr.	Oct., 1953	U.O.P.	Procon	Procon
*Columbian Carbon Co.	Seminole, Texas	Sulfur Recovery Unit			Under Constr.				
*Commercial Solvents Corp.	Sterlington, La.	Ammonium Nitrate Plt.	225 tons		Planning				Ford, Bacon & Davis
		Ammonia	200 tons		Planning	Aug., 1953			Ford, Bacon & Davis
		Methanol	9,250 bbls.		Planning	Aug., 1953			Ford, Bacon & Davis

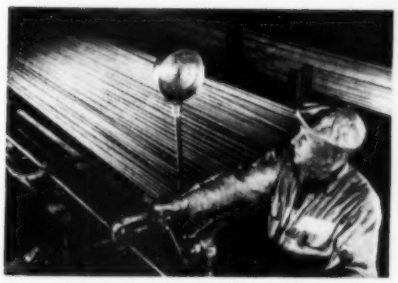
CONSTRUCTION **BOXSCORE**: Refineries and Other Plants

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Consolidated Chemical Industries, Inc.	Baytown, Texas	Acid Unit	600 tons		Under Constr.	End 1953			
Continental Oil	Lake Charles, La.	Refinery Expan.	40,500 bbls.	$27 million	Completed		U.O.P.	Badger Div., Conoco, Procon	Badger Div., Procon
Cosden Petroleum	Big Spring, Tex	Avia.-Gaso. Facl.	2,500 bbls.	$3,000,000	Planning	3rd Qtr. 1954			
Crown Central Pet.	Houston, Texas	Crude Topping	2,350 bbls.	$265,000	Design				
Crown Central	Houston	Cat. Cracker	2,400 bbls.						
Crown Central Pet. Company	Pasadena, Texas	Addition to Ref		$545,863	DPA Certified				
Danaho Ref. Co.	Pettus, Texas	Cat. Crker, Cat. Poly, Expan.	3,500 bbls. 9,500 bbls.			1954 1954			
Delta Chemical Co.	Buras, La.	Petrochemical Plt.	70 tons		Planned				
Diamond Alkali	Houston, Texas	Petrochemicals		$2 million	Contracted				Brown & Root
Dow Chemical Co.	Freeport, Texas	Ethylene Dibromide		$8.5 million	DPA Certified				
Dow Chemical	Texas City, Tex	Research Fac.		$2.6 million	Under Constr.	1953			Southwestern
Dow Chemical	Freeport, Texas	Styrene Plastics		$1.6 million	Under Constr.			Braun	Braun
Dow Chemical	Freeport, Texas	Benzene Addi.		$1.2 million	Certified DPA				
Dow Chemical Co.	Freeport, Texas	Ethyl-Dow Plt.			Under Constr.	1953	Staff	Staff	Tellepsen
Du Pont	Beaumont, Tex.	Methionine Plt.		$4,000,000	Planning				
Eastern States Pet.	Houston, Texas	Ethylene Mfg.		$4 million	Projected			U.O.P.	
Eastern States Pet.	Houston, Texas	Rehab. Closed Plt.			Army Contract				
*Eastman Kodak Co.	Longview, Tex.	Polyethylene Plt.	20,000,000 lbs./yr.		Projected				
Esso Standard	Baton Rouge	Aromatics Fac.			Under Constr.	2nd Qtr., 1954			Staff
Esso Standard	Baton Rouge	Crude Distill.			Under Constr.	2nd Qtr., 1954		S.O.D.	Kellogg
Esso Standard	Baton Rouge	Cat. Cracker	31,000 bbls.		Under Constr.	2nd Qtr., 1954		S.O.D.	Kellogg
Esso Standard	Baton Rouge	Crude Pipe Still	60,000 bbls.		Under Constr.	2nd Qtr., 1954		S.O.D., Kellogg, Ref. Eng.	Kellogg
Esso Standard	Baton Rouge,La.	Iso-octyle & Trideeyl Mfg. (Alcohol)	5,540 bbls.		Announced	2nd Qtr., 1954		S.O.D., Parsons	Parsons
*D. D. Feldman Co.	Lake Arthur, La.	Petrochem. Plt.		$843,000	Applied for certificate of nesessity				
*Foster-Grant Co.	Baton Rouge, La.	Styrene Monomer Plt.						Foster-Grant	
Gilmore Refineries	Odessa, Texas	New Refinery	50,000 bbls.	$40 million	Design				Ford-Bacon-Davis
Goliad Corp.	Lavaca Co., Tex.	Propane, Isobutane Nat. Gasoline		$2.7 million	DPA Certified				
Great Southern	Corpus Christi	Platformer Off		$5 million	Under Constr.	3rd Qtr., 1953		Fluor	Fluor
Great Southern Chemical Corp.	Corpus Christi, Texas	Platforming and Udex Units	4,000 bbls.		Under Constr.	3rd Qtr., 1953	U.O.P.	U.O.P., Procon	Procon
*Gulf Oil	Pt. Arthur, Tex	Exp. Ethylene Fac.			Considering				
Gulf Oil	Port Arthur	Sulfuric Acid	300 tons	$2,318,855	Under Constr.	Late 1953		Leonard Constr.	Leonard Constr.
Heyden Chemical & Monsanto Chemical	Texas City, Tex	Methanol Plt.	1,600 bbls.	$8,000,000	Projected	Jan., 1955			
Humble O&R Co.	Baytown, Texas	Cat. Light Ends Recov. Unit	37 Mmcf. Wet Gas	$4 million	Under Constr.	4th Qtr., 1953		Fluor	Fluor
Humble O&R Co.	Baytown, Texas	Propane Deasphalting Unit	28,000 bbls.	$5 million	Awaiting Materials	Feb., 1954			Kellogg
Humble O&R Co.	Baytown, Texas	Paraxylene Plt.	66,000 lbs.		Completing				C. F. Braun
Humble O&R Co.	Baytown, Texas	Cat. Poly.	4500 bbls.	$5,200,000	Engineering	May, 1954	Hydrocarbon	Hydrocarbon	Hydrocarbon
Humble & Consolidated Chemical Industries, Inc.	Baytown, Texas	Sulfuric Acid			Planning				
*Ingram Products	Mereaux, La.	Refinery Modernization	7,000 bbls.		Under Constr.	Early, 1954	U.O.P.	Procon	Procon
Jergins Oil Co. of Texas	Dewitt, Texas	Comp. Stripper Plt.			Authorized				
Kerr-McGee Oil	Moore Co., Tex.	Natural Gaso.	55 Mmcf	$850,000	Under Constr.	1953		Dresser, Staff	Dresser
Kolker Chemical Works, Inc.	Houston	Lindane		$1 million	Planning				
Levelland Refining	Amarillo, Texas	Cat. Crk.; Poly.	3,000/150 bbls.	$2.4 million	Design				
Lion Oil Co.	Luling, La.	Chemical Plt.	300 tons	$31 million	Under Constr.	Mid 1954		Chemico	Lummus
Lone Star Gas Co.	Parker County, Texas	Nat. Gasol. Plt.	45 Mmcf	$700,000	Completing			Staff	Staff
Magnolia	Hurricane Creek Field, Beauregard Parish, La.	Casinghead Gasoline Plt.			Designed				
Magnolia Petroleum	Beaumont, Tex.	Therm. Cat. Reforming	17,000 bbls.	$10 million	Under Constr.	Late, 1954	Soc.-Vac.		Lummus
Magnolia Petroleum	Chaison, Texas	Cooling Facil.			Engineering	1953		Fluor	Fluor
Magnolia Petroleum	Midland Co., Texas	Nat. Gas & Butane		$8.3 million	Certified DPA				
Mayfair Minerals	McAllen, Texas	Natural Gas Plt.			Announced				
*McMurrey Refining	Tyler, Texas	HF Alkylation	1,400 bbls.		Under Constr.	End, 1953			
McMurrey Refg. Co.	Tyler, Texas	Pet. Refining		$70,000	DPA Certified				
*McMurrey Refining	Tyler, Texas	Platforming Unit	5,000 bbls.		Engineering		U.O.P.	Procon	Procon
*McMurrey Refining	Tyler, Texas	Crude Unit	12,500 bbls.		Under Constr.	Oct., 1953			
		Decarbonizing Unit	8,000 bbls.		Under Constr.	Oct., 1953		Blaw-Knox	Blaw-Knox
Monarch Refining	San Antonio, Texas	Cat. Crk. Poly. Unit	5,000 bbls.	$3,000,000	Under Constr.	Completing		U.O.P., Koch	Koch
		Crude Unit	5,000 bbls.						
Monsanto	Texas City, Tex.	Vinyl Chloride		$7.3 million	Announced				
*Monsanto Chemical	Site not Finalized	Polyethylene Plt.	66,000,000 lbs./yr.						
Natural Gasoline Co.	Hawkins, Texas	Plt. Expan.	†3 Mmcf		June, 1953			Gas Plt. Constr.	Gas Plt. Constr.
Onyx Refining Co.	Abilene, Texas	Platformer	650 bbls.		Design	1953	U.O.P.	Procon	Procon
		Expansion	†500 bbls.		Planned				
Pan American Refining	Texas City, Tex.	Alky. Expan.		$2,800,000	Under Constr.	Aug., 1953		McKee	McKee
Pan American Refining	Texas City	Refinery Expan.	3,000 bbls.		Under Constr.	Dec., 1953		McKee	McKee
Pan American Refining	Texas City, Tex.	Fluid Cat. Cracking	30,000 bbls.	$13,000,000	Under Constr.	Aug., 1953		Lummus	Lummus
Pan American Refining	Texas City	Poly. Unit	†2,400 bbls.		Under Constr.	Aug., 1953		Lummus	Lummus
Pecos Petroleum	Pecos, Texas	Aromatics Expansion	240/260 bbls.		Planned				
Petrolite Corp.	Sweeney, Texas	Pet. Ref.		$25,899	DPA Certified				
Petrolite	Destrehan, La.	Pet. Ref.		$60,000	DPA Certified				
*Phillips Chemical	Houston, Texas	Ammonia Plt.			Under Constr.	Late, 1953		Chemico	Hydrocarbon Constr.
*Phillips Chemical	Houston, Texas	Add to Ammonium Sulfate Plt.			Under Constr.	Late, 1953		Phillips Chem.	Rust

* TABLE CONTINUED ON PAGE 200

Chase Antimonial Admiralty

(a patented alloy)



Every Chase Antimonial Admiralty heat exchanger tube is tested to withstand at least 1,000 pounds per square inch water pressure.

Meets every test for Heat Exchanger Tubes

Chase flattening test, index of Antimonial Admiralty tube's physical quality and ability to withstand bending or end flaring.

This Chase metallurgist is checking the size and uniformity of grain of Chase Antimonial Admiralty heat exchanger tubes.

When you put Chase Antimonial Admiralty* tubes into a heat exchanger you *know* they'll stand up for years. It isn't only that we make certain there's enough antimony to resist dezincification. Chase heat exchanger tubes are carefully tested and retested for *every* physical and chemical property required to meet actual field conditions. It pays to insist on Chase Antimonial Admiralty.

*U.S. Pat. No. 2,061,921

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CONSTRUCTION **BOXSCORE**: Refineries and Other Plants

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
*Phillips Chemical	Etter, Texas	Inc. Nitric Acid Capacity			Under Constr.	Late, 1953		C & I.	Ch. Pro.
Phillips Chem. Co.	Harris Co., Tex.	Nitro. Fertilizer	250 lbs.		Approved	Dec., 1953			
Phillips Chem. Co.	Houston, Texas	Phosphate	405 lbs.		Under Constr.	Dec., 1953		Rust	Rust
Phillips Pet.	Borger, Texas	Alky. Expan.		$15.5 million	Under Constr.	Sept., 1953		Phillips	Phillips
Phillips Pet.	Midland Co., Texas	LPG Ext. Fac.			Completed			Phillips	Phillips
Phillips Petroleum	Houston Texas	Petrochemicals	400 tons	$38 million	Completing			Phillips	Fish
Phillips Petroleum	Borger, Texas	Cyclohexane & Cyclopentane Prod. Fac.						Phillips	Bowman-Chase
Phillips Pet. Co.	Borger, Texas	LPC Prod. Fac.			Completed			Phillips	Bowman-Chase
Phillips Pet.	Etter, Texas	Increase Cap. of Nitric Acid	†110 tons					C. & I.	Ch. Pro.
Phillips Pet. Co.	Upton Co., Tex.	Central Fract.			Authorized	1953			
Phillips Pet. Co.	Upton Co., Tex.	Natural Gasoline Plt.	60,000 cf.		Under Constr.	Oct., 1953		Phillips	Phillips
Pontiac Refining	Corpus Christi	Av-Gas Expan.		$2 million	PAD Certified				
Port Fuel Oil Co.	Brownsville, Texas	Vacuum Distillation	1,500 bbls.	$75,000	Completing			Staff	
Premier Petroleum	Ft. Worth, Tex.	Refinery Expan.		$3.6 million	DPA Certified				
*Premier Petroleum	Ft. Worth, Tex.	Cat. Crker.	2,600 bbls.	$2,000,000	Contracted	Mid, 1954	U.O.P.	Ref. Eng.	Ref. Eng.
Premier Pet. Co.	Longview, Tex.	Cat. Poly. Plt.			Under Constr.				
Pure Oil	Smiths Bluff	Basic Refining		$10.8 million	Announced	1953			
Pure Oil	Smiths Bluff	Cat. Poly.			Under Constr.	1953		Kellogg	Kellogg
Pure Oil	Smiths Bluff	Expan. Alkyl.	1,900 bbls.	$390,000	Under Constr.	1953		Kellogg	Kellogg
Pure Oil	Smiths Bluff	Orthoflow Crk.	15,000 bbls.		Under Constr.	1953		Kellogg	Kellogg
Pure Oil	Smiths Bluff, Texas	Feed Prep-Vac Flash	20,000 bbls.		Under Constr.			Kellogg	Kellogg
Reef Fields Gasoline Corporation	Big Spring, Tex	Gasoline Plt.	34 Mmcf.	$6,000,000	Completing			Delta	Delta
Runnels Gas Products Corp.	Runnels Co., Texas	Gaso. & Prem. Maint. Plt.	20 Mmcf.	$3 million	Planning				
Shamrock O&G	Sunray, Texas	Sulfuric Acid Sludge Recov.	35 tons		Completing			Monsanto	Leonard
Shamrock Oil & Gas Corp.	McKee, Texas	Gaso. Ref. Treater		$80,000	Planning				
Shamrock O&G	Sunray, Texas	Aviation Alky.	16,000 bbls.	$2 million	Completing			Kellogg	Gas Plt. Constr.
Shell Chemical Corp.	Houston	Ethylene Plt., Alt.		$629,000	Under Constr.	Aug., 1953		Fluor	Fluor
Shell Chemical	Houston, Texas	Epon Resins, Bisphenol Mfg.			Completing			Badger	Badger
Shell Oil Co.	Deer Park, Tex.	Pet. Ref.		$300,000	DPA Certified				
Shell Oil Co.	Houston, Texas	Platforming Unit	16,000 bbls.	$12 million	Completed			U.O.P.	Procon
Shell Oil	Norco, La.	Expansion	†25,000 bpd.	$41 million	Under Constr.	3rd Qtr., 1954			Pritchard, Foster Wheeler, McKee
Shell Oil	Houston, Texas	Av-Gas Components		$1 million	Certified DPA				
Sid Richardson Refining Co.	Texas City, Tex.	Refinery Alterations	30,000 bbls.		Under Constr.			Staff	Staff
*Sinclair Refining	Houston, Texas	Expan. Cat. Crker, Crude Still, Vacuum Unit, Trting Boiler	25,000 bbls.	$33,000,000	Under Constr.	Fall, 1953			Braun, Fluor, White
*Southern Production Co.	Brazoria Co., Texas	Liquid Petroleum Prod. Fac.	190 Mmcf.	$4,844,000	Under Constr.	Dec., 1953			Stearns-Roger
South Texas Corp.	Nueces Co., Tex.	Expanded Products Mfg.			Announced				
Southwestern	Corpus Christi	Cat. Crk.-Poly.	5,000-200 bbls.	$5.5 million	Completing		U.O.P.	Ref. Eng.	Ref. Eng.
*Spencer Chemical	Orange, Texas	Polyethylene Plt.	45,000,000 lbs./yr.	$15,000,000	Planned	Spring, 1955	I.C.I. of England	Staff	Quaker Valley Constr.
Stanolind Oil	Superior, La.	Hydroforming			Considered	1953			
Stanolind O&G	Sundown, Texas	Gas Plt. Increase	†23 Mmcf		Completed			Staff	Blaw-Knox
*Stanolind O&G	Pettus, Texas	Sales Gas Fac.	12.5 Mmcf		Engineering	1st Qtr., 1954		Staff	
*Stanolind O&G	Oakville, Texas	Gas Injection	25 Mmcf		Considered	1st Qtr., 1954		Staff	
Suntide	Corpus Christi	Cat. Cracker	15,000 bbls.		Completed		U.O.P.	Lummus-U.O.P.	Lummus
Suntide Ref. Co.	Corpus Christi	Crude Oil Ref.	30,000 bbls.	$15 million	Under Constr.	1953	Lummus	Lummus	Lummus
Taylor Oil & Gas Company	Corpus Christi, Texas	Platform. Unit	5,000 bbls.		Under Constr.	Aug., 1953	U.O.P.	U.O.P.	Staff
Taylor O&G Co.	Corpus Christi	Aromatics Fac.	3,750 bbls.	$3.7 million	Postponed		U.O.P.	U.O.P.	Staff
Texas City Chemical	Texas City, Tex.	Dicalcium Phos. phate Plt.	300 tons	$7 million	Completing		Chemico	Chemico	Chemico
		Sulfuric Acid Plt.	300 tons	$3 million	Completing		Houdry	Houdry	Kaiser
Texas City Refining	Texas City, Tex.	Modernization, Cat. Cracker HF Alkylation							
Texas Eastman	Longview, Tex.	Petrochemicals	20,000 bbls. Propane	$5.7 million	Partial Oper.				
The Texas Co.	Paradis, La.	Gaso. Plt.			Under Constr.				
The Texas Co.	Port Arthur, Texas	Addition Cracked Naphtha Stabilization Fac.	25,000 bbls.		Under Constr.	3rd Qtr., 1953		The Texas Co.	Caruth-Dishman
The Texas Co.	Port Arthur, Texas	Catalytic Reformer	20,000 bbls.	$1,300,000	Under Constr.	2nd Qtr., 1954		U.O.P.	
The Texas Co.	Amarillo, Texas	Expan. & Mod. Cat. Cracker Atmos. Crude Pipe Still, Delayed Coker, Alky. Unit, Cat. Poly., Treating & LPG Handling Fac.	†7,500 bbls.	$20,500,000	Under Constr.	End, 1954		Kellogg, U.O.P.	Kellogg
The Texas Co.	El Paso, Texas	Expan. & Mod. Atmos. Crude Pipe Still, Cat. Cracker, Delayed Coker, Cat. Poly., Treating & LPG Handling Fac.	†5,400 bbls.		Under Constr.	End, 1954		Foster Wheeler, U.O.P.	Foster Wheeler
Texas Gas Products Corporation	Rankin, Texas	Gas Plt. Expan.			Under Constr.	1953		Texas Natural	Texas Natural
Texas Gas Products Corp.	Upton, Midland, Regan and Glasscock Co., Texas	Nat. Gas		$2.9 million	DPA Certified				

• TABLE CONTINUED ON PAGE 201

BEAIRD-INGERSOLL-RAND

Packaged Compressor Plant

Lowest Cost Per Horsepower Installed

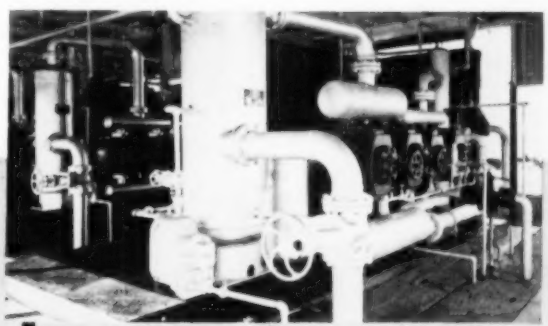
MAGNOLIA PETROLEUM COMPANY uses gas lift to produce oil wells in Baldwin Field, Texas. As gas demand for lift operations varies considerably, it is necessary to provide an ample supply of gas and yet maintain a constant pressure at the well head. To do this, Magnolia has installed a bank of four Beaird-Ingersoll-Rand packaged compressor plants. These units, equipped with 4-cycle engines and automatic speed and pressure regulators, vary their speed automatically from 50% to 100% to maintain a uniform gas pressure without the necessity of popping off or flaring.

The four units were assembled at the factory and transported directly to location as complete units. Speed and pressure controls are integral parts of the packaged plants.

Let us tell you about the economy of using Beaird-Ingersoll-Rand packaged compressor plants—singly or in multiple unit installations.

Meets varying gas demand —

HOW CONSTANT GAS PRESSURE IS ASSURED IN A GAS LIFT OPERATION



These four Beaird-Ingersoll-Rand packaged compressor plants have a total of 715 horsepower. Each unit is complete with Ingersoll-Rand gas engine-driven compressor, Young Radiator and all components usually found in permanent compressor stations. Other sizes from 110 h.p. to 550 h.p. per unit.

PACKAGED COMPRESSOR PLANTS

CAST STEEL FITTINGS

PRESSURE BULK STORAGE

ANHYDROUS AMMONIA EQUIPMENT

L.P. GAS SYSTEMS

BEAIRD

MACHINING
FABRICATING
STEEL WAREHOUSE

THE J. B. BEAIRD COMPANY, INC.

Shreveport, Louisiana

BEAIRD *Cast Steel Fittings*

Fittings that fit

Why Beaird Fittings Fit

You admire the sheer good looks of a piping installation as much as you appreciate its ability to withstand years of heavy use. And you know what a difference it makes in operation when the fittings are properly trued-up, all down the line. That's why Beaird has devoted a lot of attention, in the twenty-seven years it has made them, to producing fittings of exceptional trueness. That's why the companies who use them agree that *Beaird fittings fit.*

FLANGES FULLY BACK-FACED — provides smooth seat for stud bolt nuts — allows uniform stressing of bolts.

BOLT HOLE CIRCLES AND FLANGE CIRCUMFERENCES CONCENTRIC WITH BORE — assures true alignment of bore when flanges and bolt holes are lined up — speeds installation.

GASKET FACES MACHINED WITH FINE PHONOGRAPHIC FINISH–grips gaskets firmly—prevents leaks—reduces gasket replacement.

Ask your supply house for the new catalog of Beaird cast steel fittings — or write to us direct.

THE J. B. BEAIRD COMPANY, INC. SHREVEPORT, LOUISIANA

BEAIRD

MACHINING FABRICATING STEEL WAREHOUSE

PACKAGED COMPRESSOR PLANTS

CAST STEEL FITTINGS

PRESSURE GAS STORAGE

ANHYDROUS AMMONIA EQUIPMENT

L P GAS SYSTEMS

CONSTRUCTION **BOXSCORE**: Refineries and Other Plants

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
United Carbon Co.	Shamrock, Texas	Carbon Black	68,500 lbs.	$1.5 million	Under Constr.				
United Gas Pipe Line	Sterlington, La.	Dehydration	†25,000 mcf		Under Constr.				Staff
Universal Oil Products	Mooringsport, La.	Synthetic Cat. Mfg.			Announced				
*Warren Petroleum Corp.	Houston, Tex.	Petrochem. Plt.				Jan., 1954			
West Texas Gas Co.	Fritch, Texas	Plt. Mod.		$300,000	Completing			Anderson-Baird	
Wickett Refining	Wickett, Texas	Thermal Crker	2,000 bbls.		Under Constr.				
ROCKY MOUNTAIN									
Allied Chemical & Dye Corp.	La Platte, Nebr.	Fertilizer			Under Constr.	May, 1954		Girdler	Catalytic Constr.
Atlantic Refining Co.	Lovington, N.M.	Natural Gas	25 Mmcf.		Projected				
Bay Petroleum	Denver, Colo.	Fluid Cat. Crk.	3,500 bbls.	$1.9 million	Completing		U.O.P.	Procon	Procon
Bay Petroleum	Denver, Colo.	Crude Expan.	6,000 bbls.		Completing			Procon	Procon
Bureau of Mines	Rifle, Colo.	Cat. Ref. Demonstration Plt.		$36,000	Proposed				
Continental Sulphur & Phosphate Corp.	Thermopolis, Wyoming	Sulfur Extraction			Planning				Chemico
El Paso Natural Gas Company	Blanco, N. M.	Comp. Dehyd. & Gaso. Plt.	180 Mmcf		Completing			Fluor	Staff
El Paso Natural Gas	Gallup, N. M.	Fractionation			Completing			Fluor	Staff
El Paso Natural Gas Company	San Juan Co., N. M.	Gasoline Plt.	4,500 bbls.	$3 million	Completing			Fluor	Staff
Empire Pet. Co.	Denver, Colo.	Crude Expan.	†3,500 bpd		Announced				
Frontier Ref. Co.	Cheyenne, Wyo.	Plt. Add.	6,500 bbls.	$717,000	Projected	Sept., 1953	U.O.P.	U.O.P.	
Garfield Chemical & Mfg. Corp.	Salt Lake City	Sulfuric Acid		$2.5 million	Plan				
General Pet. Corp.	Worland, Wyo.	Gasoline Ext. & Sulfur Recov.	8 Mmcf	$4 million	Under Constr.			Fluor	
Husky Oil Co.	Cody, Wyoming	Reformer	1,000 bbls.	$350,000	Under Constr.	Aug., 1953	Atlantic	Grebe & Doremus	Grebe & Doremus
Husky Oil	Cody, Wyo.	Gas-Oil Desulfurizer	600 bbls.	$300,000	Under Constr.	Aug., 1953		Grebe & Doremus	Grebe & Doremus
*Imperial Sulphur & Acid Co.	Farmington, N. Mex.	Sulfur Plt.			Under Constr.				
Malco Ref.	Prewitt, N. M.	Pet. Ref.		$239,500	DPA Certified				
Malco Refineries	Bloomfield, N.M.	Refinery			Under Constr.				
Malco Refineries	Artesia, N. M.	Expansion	†2,000 bbls.		Planned				
McNutt Oil & Ref. Company	Brickland, N.M.	Platformer	600 bbls.	$300,000	Design	1953	U.O.P.	U.O.P.-Procon	Staff
Oriental Refining Co.	Denver, Colo.	Perco Cyclover-sion Unit	1,500 bbls.		Under Constr.				
Phillips Chem.	Eunice, N.M.	Sulfur Extrac.	100 tons	$1.5 million	Contracted				
Phillips Petroleum	Lea City, N.M.	Natural Gasoline		$27,150	PAD Certified				
Phillips Petroleum	Great Falls, Montana	Refining		$3 million	Certified DPA				
Phillips Petroleum Co.	Woods Cross, Utah	Expansion			Projected				
Proven Oil & Refining	Florence, Ariz.	Refinery	15,000 bbls.	$18.3 million	Under Constr.	1955		Ebasco and Lummus	
Salt Lake Refining	Salt Lake City,	Acid Treating Unit		$400,000	Completed			Bechtel	Bechtel
Salt Lake Refining	Davis Co., Utah	Pet. Ref.			Completed				
*Socony-Vacuum Oil Co.	Manderson, Wyo.	Nat. Gas Plt.		$15,000,000	Projected				
Sinclair Refining Co.	Sinclair, Wyo.	Refinery Addit.	6,000 bbls.	$600,000	Completing				
Standard Oil (Ind.)	Casper, Wyo.	Alkylation Unit	575 bbls.		Design	Mid 1954			
Sullivan Mining Co.	Kellogg, Idaho	Sulfuric Acid Plt.	300 tons		Under Constr.	January, 1954		S & B	S & B
*Utah Chemical Co.	Sanpete Valley, Utah	Ammonia Plt.	278 tons	$18,800,000	Planned				Cat. Constr.
Utah Oil Ref.	Salt Lake City	Expansion		$1 million	Under Constr.	1953		Staff	CB&I
Warren Pet. Corp.	Monument, N.M.	Expansion	†23 Mmcf.		Under Constr.	1953		Staff	Staff
*Warren Petroleum	Lea Co., N.M.	Nat Gaso. Plt.	22 Mmcf.		Under Constr.	Dec., 1953		Fluor	Fluor
Western States Refg.	Salt Lake City	Topping; Crker.	3,000/2,200 bbls.	$1.1 million					
WEST COAST									
Allied Chemical & Dye Corp.	Port Chicago, Calif.	Aluminum Fluoride Plt.		$1 million	Completed			Bechtel	Bechtel
Amoniaco Corp.	Brea, Calif.	Ammonia Plt.		$13,000,000	Under Constr.	Summer, 1954		Braun	Braun
Canned Co.	Hanford, Calif.	Motor Gasoline & Distillate			Announced	1953			
Carbide & Carbon Chemicals Company	Torrance, Calif.	Polyethylene Plt.	60 million lbs./yr.	$36 million	Under Constr.	End, 1954			
Douglas Oil Co. of Calif.	Bakersfield, Calif.	Polymerization Unit	100 bbls.	$261,000	Completing		U.O.P.		
Dow Chemical Co.	Torrance, Calif.	Styron Mfg. Plt.			Under Constr.	Fall, 1953			Bechtel
Envoy Pet.	Long Beach, Calif.	Asphalt Fac.	700 bbls.						
Eureka Refining	Long Beach, Cal.	Cat. Crker.	6,000 bbls.	$2.2 million					
Filtrol Corp.	Vernon, Calif.	Ammonium Sulfate	150 tons	$5,000,000	Under Constr.	Jan., 1954		J. H. Pomeroy	
General Petroleum	Torrance, Calif.	Therm. Cat. Reform.	19,000 bbls.	$9 million	Projected	Fall, 1954		Soc-Vac., Bechtel	Bechtel
General Pet. Corp.	Ferndale, Wash.	Refinery	35,000 bbls.	$35 million	Under Constr.	August, 1954		Bechtel	Bechtel
*General Petroleum	Vernon, Calif.	Naphthenic Acid Plt.		$210,000	Under Constr.	Fall, 1953		E&A	E&A
*General Petroleum	Torrance, Calif.	Depropanizer		$350,000	Engineering	1953		E&A	E&A
Hancock Oil Co.	Long Beach, Cal.	Ethylene Glycol	20,000 bbls.		Under Constr.			Badger-Div.	Badger-Div.
Hancock—Calif.	Long Beach	Aviation Gaso.		$3 million	PAD Certified				
International Mineral and Chemical	San Jose, Calif.	Chemical Process Plt.		$425,000	Completed				Bechtel
Mohawk Petroleum	Bakersfield, Calif.	Jet Fuel Prod.		$3 million	Announced				
Monsanto Chemical Company	Avon, Calif.	Phenol			Under Constr.	Early, 1954			United Engrs. & Constructors
Navy	San Joaquin, Calif.	Natural Gas Plt.	50,000 mcf	$5 million	Under Constr.				Parsons-Macco
Pacific Oil & Refining Co.	Puget Sound, Wash.	Refinery	10,000 bbls.		Projected				
Richfield Oil	Watson, Calif.	Expansion; Cat. Cracker; Aromatics	20,000 bbls.	$43 million	Under Constr.	1954		Braun	Fluor
Richfield Oil	Los Angeles	Ref. Expan.	†20,000 bbls.	$40 million	Under Constr.	Aug., 1954			Fluor
Rothschild Oil	Santa Fe Springs, Calif.	Cat. Cracker	6,000 bbls.	$2 million					Braun
Shell Chemical	Ventura, Calif.	Synthetic Ammonia Plt.	150 tons.		Under Constr.	Oct., 1953		Kellogg	Kellogg, Gibbs & Hill

CONSTRUCTION **BOXSCORE**: Refineries and Other Plants

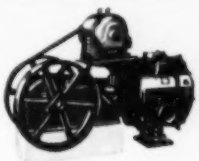
COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Shell Oil Co.	Wilmington, Calif.	Distillation Tower	50,000 bbls.	$7 million	Under Constr.	Late 1953		Bechtel	Bechtel
Shell Oil Co.	Ventura, Calif.	Nat. Gaso. Plt. Revisions & Extensions		$1,000,000	Under Constr.	Sept. 1, 1953			Fluor
Signal Oil & Gas	Los Angeles, Calif.	Butanes-Iso-butane		$500,000					
Standard (Calif.)	Richmond, Calif.	SynthetePhenol	35 mln. lbs./yr.	$4 million	Under Constr.	March, 1954		Standard	Stone & Webster
*Standard (Calif.)	El Segundo, Calif.	Alky. Plt. Add.							Fluor
*Standard (Calif.)	E Segundo, Calif.	Paraxylene Plt.							Fluor
*Standard (Calif.)	El Segundo, Calif.	Offsite Fac.							Macco
Standard Oil (Calif.)	El Segundo	Cat. Crker	36,000 bbls.	$20 million	Engineering	Sept., 1954		Fluor	Fluor
Standard (Calif.)	El Segundo, Calif.	Residuum Strper	52,000 bbls.		Engineering	March, 1954		Kellogg	Kellogg
Stauffer Chemical	Compton, Calif.	Sulfuric Acid		$57,070	Engineering				
Stauffer Chemical	Richmond, Calif.	Sulfuric Acid		$283,500					
Sunset Oil Co.	Torrance, Calif.	Expansion		$1,000,000	Planned			Clark & Gesselin	
Tide Water Assoc.	Avon, Calif.	De-ethanizer		$865,000	Completing			Bechtel	Bechtel
Tide Water Assoc. Oil Co.	Avon, Calif.	Hydrogen Sul-fide Stripper		$250,000	Completing			Barnes	Barnes
Union Oil (Calif.)	Los, Angeles	Revisions of Tankage & Oil Transfer Sys.		$4,000,000	Under Constr.			Fluor	Fluor
Union Oil (Calif.)	Los Angeles	Facilities to Re-duce Hydro-carbon Losses		$515,000	Under Constr.			E & A	Buckner
FOREIGN									
Canada									
British American Oil Company	Clarkson, Ontario	Ref. Additions & Fld. Cat. Crker.	8,300 bbls.	$8 million	Planning	May, 1954	Kellogg	Canadian Kellogg & Barnes	Canadian Kellogg & Barnes
British American Oil Co.	Montreal	Cumene Plt.	600 bbls.	$800,000	Under Constr.	Dec., 1954	U.O.P.	U.O.P. & Staff	Barnes
*Compagnie Financiere Belge Des Petroles (Petrofina)	Quebec, Canada	Refinery			Planned				
Campbell Absorption Plant, Ltd.	Alberta, Canada	Natural Gaso. Plt.			Planned				
Canadian Chemical Company	Edmonton Area, Alberta	Petro Chemical Plt.		$50 million	Under Constr.	1953		Celanese-Brown & Root	Brown & Root
Canadian Industries	Montreal, Quebec	Polyethylene Mfg.		$13 million	Under Constr.	Late 1953			
Canadian Industries, Ltd.	Edmonton, Alta.	Polythene Plt.	16.6 tons		Announced	Late 1953			
*Canadian Industries, Ltd.	Maitland, Ontario	Petrochem. Plt.				End, 1953			
Canada Southern Oils	Saskatchewan	Refinery	10-20,000 bbls.	$7,000,000-$10,000,000					
Consumer's Co-Op. Ref.	Regina, Saskatchewan	Mod. & Expan. Cat. Crker, Poly Gas & Vac. Units	11,000 bbls.	$5,500,000 $8,000,000	To Begin 1953	July, 1954	U.O.P.	U.O.P.	Ref. Eng.
Hi-Way Refineries, Ltd.	Saskatoon, Canada	Cat. Crker	3,000 bbls.	$2.5 million	Under Constr.	End 1953	U.O.P.	Ref. Eng.	Ref. Eng.
Hooker Chemicals, Ltd.	N. Vancouver, B. C.	Crude Revamp Chemicals	3,500 bbls.		Projected				
*Imperial Chemical Industries of Canada	Milhaven, Ont.	Terylene Fibre	11,000,000 lbs./yr.	$20,000,000	Under Constr.	Mid 1955		Ferguson	Ferguson
Imperial Oil	Sarnia, Ontario	Quality Control Lab. Packaging & Shipping Plt and Mech. Shops		$6,000,000	Planned	1954			
Imperial Oil	Edmonton, Alberta	Lube Oil Plt.	2,000 bbls.	$10,000,000	Planned	Mid 1955			
Imperial Oil	Regina, Sask.	Mod & Expan.	†2,500 bbls.	$7 million	Planned Under Constr.	Early 1954		Staff	
Imperial Oil, Ltd	Montreal, Quebec	25% Cap. In-crease	†12,000 bbls.	$10,000,000	Planned	Early, 1954			
Imperial Oil, Ltd.	Winnipeg, Manitoba	Cat. Poly. Plt.	250 bbls.	$750,000	Planned	May, 1954		Staff	
Kamloops Refinery Syn.	Kamloops, British Columbia	Topping Unit, TCC Cat. Crk., Cat. Poly., Gas Recovery	2,500 bbls.	$3 million	Projected	1954		Barnes	Barnes
*Ledue Southern Absorption, Ltd.	Edmonton, Canada	Gas Absorption Plt.		$20,000,000	Permit Granted				
*Lubrizol of Canada, Ltd.	Niagara Falls, Ontario	Lube Oil Addi.			Under Constr.	End, 1953			
Midland Pet. & Pacific Pet.	Stettler, Alta.	Crude Refinery	4,000 bbls.	$2 million	Under Constr.				
*Monsanto Canada, Ltd.	Ville La Salle, Canada	Petroleum Addi Plt.		$400,000	Under Constr.	End, 1953			
North Star Oil, Ltd.	St. Boniface, Manitoba	Modernization, Cat. Cracker		$5-6,000,000	Planning				
Panther Oil and Grease Co.	Leaside, Toronto, Ontario	Grease and Compounding			Projected				
*Refinery Operators, Ltd.	Kamloops, B.C.	Refinery	5,000 bbls.	$6,000,000	Under Constr.				
*Royalite Oil Co.	Kamloops, B.C.	Refinery	5,600 bbls.		Under Constr.	Nov., 1954			
Shell Oil Co. of Canada, Ltd.	Vancouver, B. C.	Refinery Expan.	†15,000 bbls.	$10 million	Engineering	4th Qtr., 1953	U.O.P.	Fluor	Fluor
*Shell Oil Co. of Canada	Okotoks, Canada	Sulfur Ext. Plt.			Planned				
Sun Oil	Sarnia, Ont.	Refinery	15,000 bbls.	$14,000,000	Under Constr.	Fall, 1953	Houdry	Cat. Const.-Sun	Cat. Constr.
Supreme Refineries	Ogden, Alta.	Asphalt Plt.			Planning				
*Texaco Exploration Co.	Edmonton, Canada	Gas Absorp. Plt.		$20,000,000	Permit Granted				
Wainwright Refineries, Ltd.	Wainwright, Alberta	Expansion	400 bbls.		Under Constr.				
Latin America									
Brazilian Govt.	Sao Mateus (Santo) Brazil	Shale Oil Pilot Plt.	100 bpd.	$500,000					
Brazilian Investments	Niteroy, Rde J. Brazil	Refinery	20,000 bbls.		Petitioned				Kellogg
Colombian Petro-Company	Barco Conces-sion	Gas Treating Plt.	1 Mmcf	$5 million	Under Constr.				

• TABLE CONTINUED ON PAGE 205

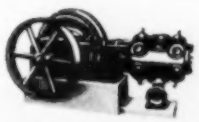
HEAVY-DUTY
"ES" COMPRESSORS

provide maximum efficiency in a
WIDE RANGE OF APPLICATIONS

. . . with unusual flexibility of drive and cylinder arrangements



OVERHEAD MOTOR

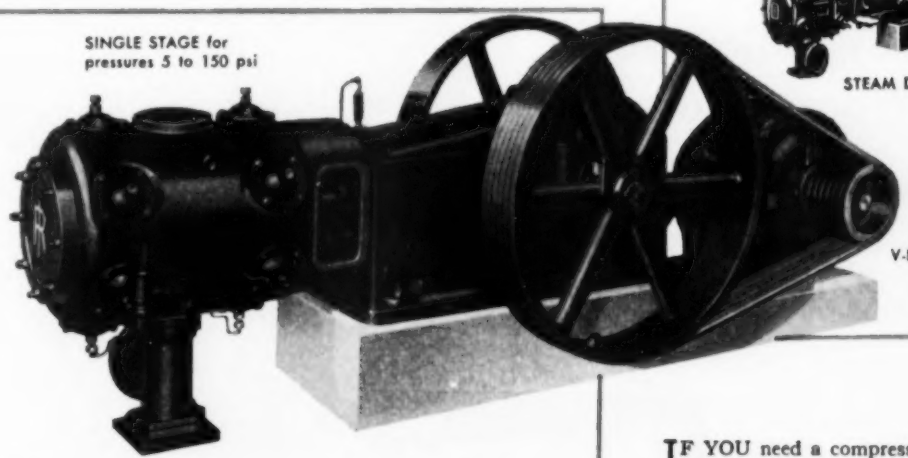


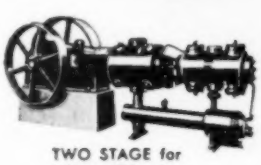
DIRECT-CONNECTED
SYNCHRONOUS MOTOR

STEAM DRIVE

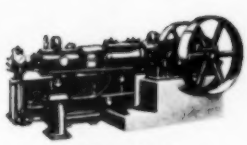
V-BELT DRIVE

SINGLE STAGE for
pressures 5 to 150 psi

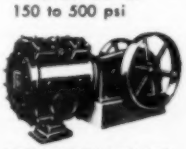




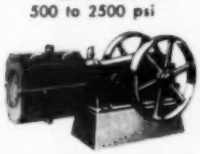
TWO STAGE for
150 to 500 psi



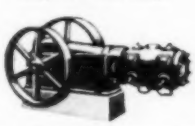
THREE STAGE for
500 to 2500 psi



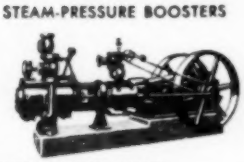
DRY VACUUM PUMPS . . .
single or two stage



STEAM-PRESSURE BOOSTERS



NON-LUBRICATED CYLINDERS
for oil-free air or gas



REFRIGERATION UNITS
for ammonia or other refrigerants

IF YOU need a compressor for any of the following purposes you should consider the Type "ES" compressor . . . a standardized, yet extremely flexible compressor built by Ingersoll-Rand, the pioneer compressor builder.

- To compress air or gas to any pressures between 5 and 2500 psi, or for pulling vacuums. (Stock cylinders are normally available for all frame sizes, see illustrations.)
- For capacities requiring from 5 to 125 horsepower. (Six frame sizes are available.)
- For continuous full-load operation day after day, week after week.
- For handling poisonous, inflammable, or other gases where leakage must be avoided.
- Where compressed air or gases must be free of all traces of oil. (Type NL cylinders require no oil, glycerine, grease or water for lubrication.)
- Where a future change in pressure conditions may call for a change in cylinder sizes.
- Where power cost is an important factor.
- To act as an economical standby unit for larger compressors whose full capacity is not required at all times.

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COMPRESSORS • TURBO-BLOWERS • ROCK DRILLS • AIR TOOLS • CENTRIFUGAL PUMPS • CONDENSERS • OIL AND GAS ENGINES

RUGGED BOSS

for Valves, Sluice Gates and Floorstands...

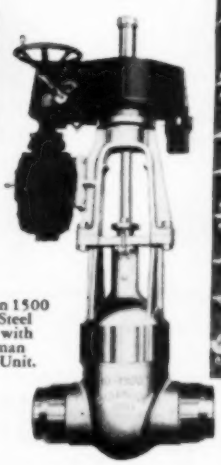
CHAPMAN'S

Motor Unit

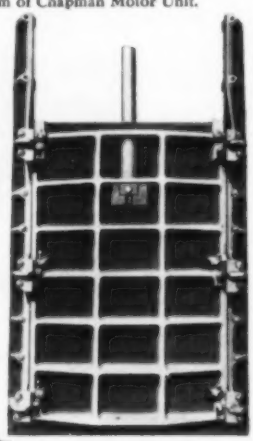
Above, Floorstand equipped with Chapman Motor Unit, Control Panel, Motor, Limit Switch and Push Button Station all completely wired. At left, Interior Mechanism of Chapman Motor Unit.

For positive control of large valves and sluice gates, the Chapman Motor Unit can safely be given your "power of attorney." The floorstands with Chapman Motor Units come to you with all wiring *complete*, so that all you have to do is bring the power leads into the connection box . . . which speeds up installation, insures proper operation, and saves wiring costs.

The Chapman Motor Unit is completely housed and thoroughly weatherproof. And the unit itself has the ruggedness of simplicity, with a slow-speed motor driving direct through two trains of spur gears. So there's no drift. The limit switch can be adjusted so the gate or valve closes to the exact seating position. Hand-operated, too, if the need arises. See what this modern electrically driven Motor Unit can do — *and save* — for you. Write for Catalog No. 50.



Chapman 1500 Series Steel Valve, with Chapman Motor Unit.



Chapman Standard Sluice Gate, with stem connection for Chapman Motor Operated Floorstand.

The CHAPMAN VALVE Mfg. Company

INDIAN ORCHARD, MASSACHUSETTS, U. S. A.

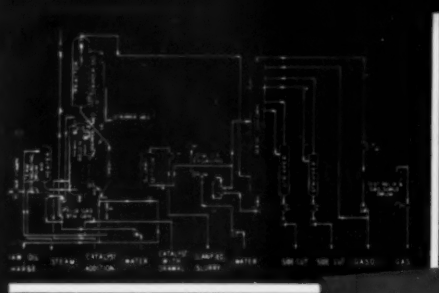
CONSTRUCTION **BOXSCORE**: Refineries and Other Plants

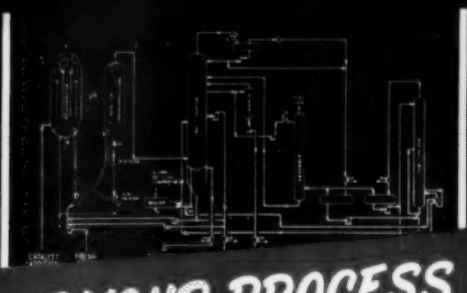
COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Colombian Petroleum	Tibu Field	Refinery	2,000 bbls.	.....	Tenders Out	.....	.....	.....	.....
Colombian Petroleum	Tibu, Colombia	Gasoline Plt. Crude Stabilizer	60 Mmcf 10,000 bbls.	.....	Engineering	4th Qtr., 1953	.....	Fluor	Fluor
*Companhia de Petroleo da Amazonia	Amazonas State, Brazil	Refinery	5,000 bbls.	.....	Studies	.....	.....	.....	.....
Conselho Nacional do Petroleo	Cubatao, Sao Paulo, Brazil	Therm. Crk. Ref. Reforming, Vis. Breaking Cat. Poly.	45,000 bbls.	.....	Under Constr.	Mid, 1954	Hydrocarbon Calif. Res., Shell Dev., Edeleanu	PA Hydro Res.	PA Hydro Res. and McKee
Conselho Nacional do Petroleo	Bahia, Brazil	Lube Oil Fac. Expansion	2,000 bbls. 2,600 bbls.	$12,000,000	Engineering Completed	.....	.....	.....	Kellogg
Conselho Nacional	Salvador, Brazil	Cat. Poly. LPG	5,000 bbls.	.....	Under Constr.	.....	.....	Kellogg-P.A., Hydro. Res.	Staff
*Conselho Nacional do Petroleo	Sao Paulo State	Refinery	30,000 bbls.	.....	Studies	.....	.....	.....	.....
The Corporacion de Fomento de la Produccion	Concon Valparaiso, Chile	Refinery	14,000 bbls.	$9 million	Planning	1953	.....	.....	.....
Coaden Pet. Corp.	San Juan, Puerto Rico	Refinery	.....	$6.5 million	Planning	.....	.....	.....	.....
Creole Pet. Corp.	Amuay Bay, Estado Falcon, Venezuela	Ref. Expan.	140,000 bbls.	$35 million	Engineering	End 1954	S.O.D.	S.O.D.	.....
*Creole Petroleum Corp.	Amuay	Fluid Hydroformer	10,000 bbls.	.....	Engineering	April, 1955	S.O.D.	S.O.D.	Foster Wheeler
N. V. Curacaosche Petroleum	Curacao, Netherlands Antilles	Lube Ref. Ext.	2,000 bbls.	.....	Under Constr.	Early 1954	.....	.....	.....
Diadema Argentina	Buenos Aires	Luboil Refining	600 bbls.	.....	Under Constr.	1954	.....	.....	.....
Empresa Nacional de Petroleo	Concon, Chile	Refinery	20,000 bbls.	$8,000,000	Under Constr.	1954	.....	P.A., Kellogg	P.A., Kellogg
International Petroleum (Colombia)	Barrancabermeja Colombia	Refinery Modernization	35,000 bbls.	$20-25 million	Under Constr.	Late 1954	.....	Foster Wheeler	Foster Wheeler
Petroleos Mexicanos	Tamaulipas, Ciudad Madero, Mex.	Enlarge Refinery Capacity	47,250 bbls.	$22,000,000	Projected	.....	.....	.....	.....
Petroleos Mexicanos	Tamaulipas, Arbol Grande Pet., Mex.	Enlarge Refinery	16,600 bbls.	.....	Project	1953-54	.....	.....	Staff
Petroleos Mexicanos	Mata Redonda, Vera Cruz, Mex.	Improvements	.....	.....	Project	1953-54	.....	.....	Staff
Petroleos Mexicanos	Poza Rica, Mex.	Expansion	†100 Mmcf	$3.6 million	Under Constr.	1954	.....	McKee	McKee
Petroleos Mexicanos	Reynosa, Mex.	Expansion	5,000 bbls.	.....	Project	1953-54	.....	.....	Staff
Petroleos Mexicanos	Salamanca, Mex.	Lube Oil and Paraffin Plt.	2,200 bbls. Lube 143,000 lbs. Wax	$25,500,000	Under Constr.	Mid 1954	Texaco	McKee	Staff
*Petroleos Mexicanos	Poza Rica, Vev.	Expan. Gas Absorption Purificating; Sulfur Mfg.	120 Mmcf	$20,000,000	Under Constr.	1954-55	.....	McKee	Staff
*Petroleos Mexicanos	Mexico, D.F.	Cap. Increase	30,000 bbls.	$7,000,000	Projected	1954	.....	.....	.....
*Petroleos Mexicanos	Tampico, Tamps	Crude Oil Refinery Mod., Vac. Dist., Cat. Crker. & Related Fac.	75,000 bbls.	$33,000,000	Projected	1954	.....	.....	.....
*Petroleos Mexicanos	Minatitlan, Vev.	Cat. Cracking	8,000 bbls.	$3,700,000	Projected	1954	.....	.....	.....
Private Group	Rio de Janeiro	Refinery	20,000 bbls.	.....	Projected	.....	.....	.....	Kellogg
Puerto Rican Oil Refining Co.	Near Ponce, Puerto Rico	Refinery	25,000 bbls.	$20 million	Projected	.....	Undetermined	Parsons, Brinckerhoff, Hall and Macdonald	.....
Rafinaria de Petroleos de Manguinhos S.A	Manguinhos, Brazil	Refinery	10,000 bbls.	10 million	Contracted	1954	.....	Kellogg	Kellogg
Refinaria de Petroleos	Rio de Janeiro	Therm. Crk.	10,000 bbls.	.....	Authorized	.....	.....	Foster Wheeler	Foster Wheeler
*Refinaria e Exploracao de Petroleo "Uniao" S.A.	Capuava, Sao Paulo, Brazil	TCC Recovery Cat. Poly.	20,000 bbls.	.....	Under Constr.	1954	Hydrocarbon Calif. Res., So-Vac.	Hydrocarbon	Hydrocarbon
Reunidas F Matarazzo	Sao Paulo, Brazil	Contact Sulfur Acid Plt.	60 tons	.....	Ordered	.....	.....	.....	Chemico
Richmond Exploration Company	Bajo Grande, Venezuela	New Refinery	35,000 bbls.	.....	Referred	.....	.....	.....	.....
Shell Co. of Venezuela	Cardon, Ven.	Comprehenive Refg.	145,000 bbls.	.....	Completing	.....	.....	.....	.....
Shell Oil Company	Cardon	Lubricating Oil	275 tons	.....	Completing	.....	.....	.....	.....
Trinidad Leaseholds, Ltd.	Trinidad	Refinery Addition	.....	$300,000	Designing	.....	.....	H.W.P.	H.W.P.
*Yacimientos Petroliferos Fiscales	Eva Peron, Argentina	Refinery	28,300 bbls.	.....	.....	.....	.....	Kellogg	Kellogg
Europe and Africa									
Albatros S.A. Pour le Raffinage de Petrol	Antwerp, Belgium	Houdriflow Cat. Crker	4,000 bbls.	.....	Under Constr.	Late 1953	Houdry	H.W.P.	H.W.P.
Albatros S.A. pou le Raffinage de Petrole	Antwerp, Belgium	Expansion	12,000 bbls.	.....	Under Constr.	1954	.....	Petrocarbon, Ltd.	Petrocarbon, Ltd.
Anglo-Iranian Oil	Kent, England	Rerun Unit	2,100 bbls.	.....	Under Constr.	Fall, 1953	.....	.....	.....
Anglo-Iranian Oil	Kent, England	Solutizer	5,400 bbls.	.....	Under Constr.	Fall, 1953	.....	.....	.....
Anglo-Iranian Oil	Kent, England	Cu Chloride Treating	4 x 7,000 bbls.	.....	Under Constr.	Fall, 1953	.....	.....	.....
Anglo-Iranian Oil	Kent, England	Acid/Soda Treat.	2,100 bbls.	.....	Under Constr.	.....	.....	.....	.....
Anglo-Iranian Oil	Kent, England	Propane Deasph.	.....	.....	Under Constr.	.....	.....	Kellogg	Kellogg
Anglo-Iranian Oil	Kent, England	Furfural Extrac.	.....	.....	Under Constr.	.....	Texaco	Lummus	Lummus
Anglo-Iranian Oil	Kent, England	MEK Dewaxing	.....	.....	Under Constr.	.....	Texaco	Foster Wheeler	Foster Wheeler
Anglo-Iranian Oil	Kent, England	Clay Contact	.....	.....	Under Constr.	.....	.....	Lummus	Lummus
Anglo-Iranian Oil	Kent, England	Fluid Cat. Crk.	10,000 bbls.	.....	Completing	.....	.....	Kellogg	Kellogg
*Anglo Iranian Oil Company	Dunkirk, France	Platformer	6,000 bbls.	.....	Planned	.....	.....	.....	.....
*Anglo-Iranian	Schindler, Germany	Furfural Trtg. Plt.	.....	.....	Under Constr.	.....	.....	.....	.....
*Anglo-Iranian	Hamburg, Germany	Distillation Unit Platformer	6,000 bbls.	.....	Planned	.....	.....	.....	.....
*Anglo-Iranian	Antwerp, Belgium	Catalytic Crker. Cat. Poly. Increase Cap. of Thermal Crker.	.....	.....	Planned	.....	.....	.....	.....
Anglo-Transvaal Consolidated Investment Co.	Vall River, Union of South Africa	Synthetic Gasoline and Diesel Oil Plt.	.....	$50-60 million	Contracted	.....	.....	Hydro. Res.	.....
Atlantique Pregil-Electro-Chemie	Donges, France	Cumene Plt.	326 bbls.	$1,000,000	Under Constr.	Jan., 1954	Hercules	Hydrocarbon	Hydrocarbon
Bataafsche Petroleum Maatschappij	Pernis, Holland	Expansion	†65,700 bbls.	.....	Under Constr.	Late, 1953	.....	.....	.....

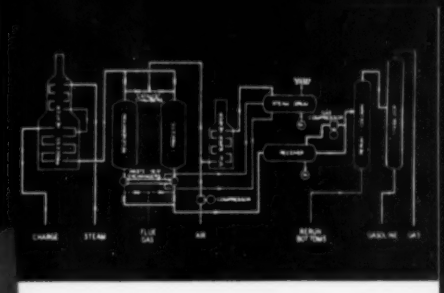
CONSTRUCTION **BOXSCORE:** Refineries and Other Plants

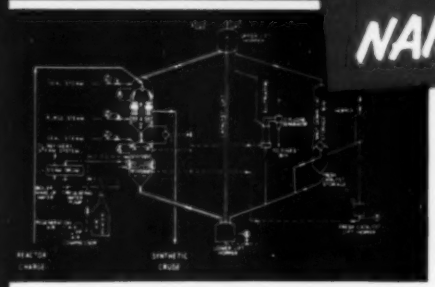
COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
*N. V. de Bataafsche Petroleum Maatschappij	Pernis, Netherlands	Luboil Ref. Exp.	1,750 bbls.		Under Constr.	Early, 1955			
		solvents Plt.	16,000 tons/yr.		Under Constr.	May, 1954			
Benzene und Pet. Co. of Hamburg	Hamburg-Finken, Werder, Germany	Expansion	660,000 bbls.		Announced				
Cie de Raffinage Shell-Berre	Berre, France	Expansion	65,000 bbls.	$31.6 million	Completing				
Cie de Raff. Shell-Berre	Pauillac, France	Distilling Expansion	12,000 bbls.		Completing				
Cie Francaise de Raffinage	La Mede, France	Cat. Crk., Gas Recov. System	11,500 bbls.		Completing		SOD	SOD, Lummus	Lummus
Compania Espagnole de Petroles, S. A.	Santa Cruz de Tenerife	Reforming Unit	5,000 bbls.	$1 million	Under Constr.	1953	U.O.P.	U.O.P.	Foster Wheeler
Condor, S.P.A. Per l'Industriale Pet. Chemica	Rho, Italy	Cat. Crker.	15,000 bbls.		Under Constr.	1953	So-Vac.	Badger Div.	Badger Div.
Condor	Rho, Italy	Atm. Dist. Plt.	45,000 bbls.		Under Constr	1953		Badger Div.	Badger Div.
Condor	Rho, Italy	TCC Unit	10,000- 15,000 bbls.		Completing		So-Vac.	Badger Div.	Badger Div.
Condor	Rho, Italy	Recov. Purification Plt., Adm. Bldg., Pwr. House			Completing			Badger Div. Staff	Badger Div. Staff
Deutsche-Amerikanische Petro-Gesellschaft (Esso)	Hamburg-Harburg, Germany	Cracking Plt. and Expansion	8,843 bbls.	$10 million	Under Constr.	Jan., 1954		S.O.D.	Gutte-Hutte
Egyptian Government	Cairo, Egypt	Crude Plt.						Lummus	Lummus
Egyptian Government	Suez, Egypt	Inc. Refn. Cap.	26,000 bbls.	$2,500 000	Planning				Lummus
*Empresa Nacional "Calvo Sotelo"	Puertollano, Spain	Shale Oil Refg.	3,000 bbls.	$46,000,000	Under Constr.	1954	Basf, Lurgo	Basf, Lurgi	Basf, Lurgi
Esso Stand. Hateana.	Genoa, Italy	Cap. Increase							
Esso Standard Refg.	Antwerp, Belg.	New Refinery Incl. Crker.	25,000 bbls.	$25 million	Completing			S.O.D.	Lummus
Esso Standard, Societe Anonyme Francaise	Port Jerome, France	Double Stage Pipestill	25,000 bbls.	$3,715,000	Under Constr.	Mid-1954		Foster Wheeler	Foster Wheeler
Garrane	Genoa, Italy	Cap. Increase							
*Greek Government	Greece	Refinery	25,000 bbls.	$20,000,000	Planned				
Gulf Oil Corp.	Antwerp, Belgium	Refinery	20,000 bbls.		Considering				
Industria Petrolifera e Chimica	Milan, Italy	Gasoline Fuel Oil Plt.	20,000 bbls.					Dr. Calogero Inglogio	
Imperial Chemical Industries, Ltd.	Wilton, Yorkshire, England	Petroleum Cracking Unit	2,000 bbls.		Under Constr.			Kellogg	Kellogg
Kali Chemie Co	Nienberg, Germany	Bead Catalyst Plt.			Licensed		So-Vac.		
Manchester Oil Refinery, Ltd.	Partington, England	New Lube Refinery	30,000 bbls.		Projected				
Mineralol-und Asphaltwerke, A.G.	Ostermoor Germany	Reconstruction	1,196 bbls.						
Monsanto Chemical Company	Britain	Add Polystyrene			Under Constr.			Staff	Staff
Montecatini Co	Ferrara, Italy	Olefin Plt.	450 bbls.	$18.6 million	Contracted	Mid 1953		Kellogg	Kellogg
A. P. Moeller	Copenhagen, Denmark	Thermal Cracking Plt.	2,000 bbls.	$3.5 million	Field Work				
National Oil Refineries, Ltd.	Llandarcy	Platformer	6,000 bbls.		Engineering	End 1954	U.O.P., Procon		Badger
National Oil Refineries, Ltd.	Llandarcy	Wax Treating	350 bbls.		Completing			Badger	Badger
*National Oil Refineries	Llandarcy.	SO_2 Kerosine Extraction			Planned				
A/S Norsk Amerikansk Mineralolekompagni	Vallo, near Tonberg, Norway	Lube Oil, Asphalt	1,000 bbls.						
Pechelbronn, S. A. E. M.	Merkwiller, France	Cap. Increase	1,550 bbls.		Authorized				
Permolio	Genoa, Italy	Cap. Increase							
Raffineries Francaise de Petrole de l'Atlantique	Donges, France	ADC Electrolytic Caustic Regeneration			Completing		Amer. Dev. Co.	Hydrocarbon	Staff
Raffineries Francaises de Petrole de l'Atlantique	Donges, France	Consolidate Refineries	50,000 bbls.	$9.4 million	Completed				
Raffineries Francaises	Donges, France	T. C. C. Unit	10,000 bbls.		Under Constr.		So.-Vac.	Hydrocarbon	Hydrocarbon
Raffineries Siciliane Oli Minerali	Augusta, Sicily	Topping Unit	20,000 bbls.		Completing			Staff	Staff
		Thermal Reforming	4,000 bbls.		Under Constr.	August, 1953		Staff	Staff
		Topping-Vacuum Unit	4,000 bbls.		Under Constr.	Sept., 1953		Staff	Staff
Refineria de Petroleos de Escombreras S. A., (REPESA)	Escombreras Spain	Lube Oil Plt.	20,000 tons/yr. Nominal Cap.		Planning	1955		Foster Wheeler	Foster Wheeler
S. A. Cone. Ref. Pet. em Portugal	Cabo Riuvo Plt., Portugal	Topping Unit	29,000 bbls.		Under Constr			Koch	Koch
S. A. Cone. Ref. Pet.	Cabo Riuvo Plt.	Cracking Unit	5,000 bbls.				So-Vac.	Hydro-Res.	Hydro-Res.
S. A. Cone. Ref. Pet.	Cabo Riuvo Plt.	Reformer	2,500 bbls.						
Shell Oil Company	Rotterdam, Holland	Distillation Plt.	13.2 million tons	$5.6 million		Late, 1953			
Sociedade Anonima Concessionaria em Portugal	Cabo Riuvo, Portugal	T.C.C. Gas Rec. Cat. Poly., Vac. Dist., Sweetening	11,000 bbls.		Under Constr.	1953	So.-Vac., Hydro-Carbon, Calif. Res. Edeleanu	Hydrocarbon	Hydrocarbon, Staff
Sociedade Anonima Concessionaria da Rafinacao de Petroleos em Portugal	Cabo Riuvo, Portugal	Kerosine Diesel & Lube Extrac.	6,600 bbls.		Engineering	1954	Edeleanu	Edeleanu	
Societe Cherifenne des Petroles	Petitjean, Morocco	Feed Prep., T. C.C. Recov.	2,700 bbls.		Engineering	1954	So.-Vac.	Hydrocarbon	Hydrocarbon
Societe Industrielle Belge des Petroles	Antwerp	Cat. Crker			Planned	End, 1954			
		Cat. Poly.			Planned	End, 1954			
Societa per l'Industria del Petrolio	La Spezia, Italy	Thermal Ref.	1,600 bbls.		Completing				
Socony-Vacuum Italiana, S.P.A.	Naples, Italy	Cat. Poly.		$724,000	Design	Late 1954	Calif. Res.	Bechtel	Bechtel
Socony-Vacuum Italiana, S.P.A.	Naples, Italy	TCC			Design	Late 1954	Soc-Vac	Bechtel	Bechtel
South Africa Coal Oil & Gas	Coalbrook, Orange Free St.	Plt. Ref. Expan.	3,500 bbls	$50.4 million	Under Constr.	1955		Kellogg	Kellogg
Stanic Industria Petrolifera	Leghorn, Italy	Coal Synthesis and Expan.	15,500 bbls. 33,000 bbls.	$20,000,000	Completing Under Constr.	Sept., 1953	S.O.D., Staff	Staff S.O.D., Staff	Staff Badger

• TABLE CONCLUDED ON PAGE 208









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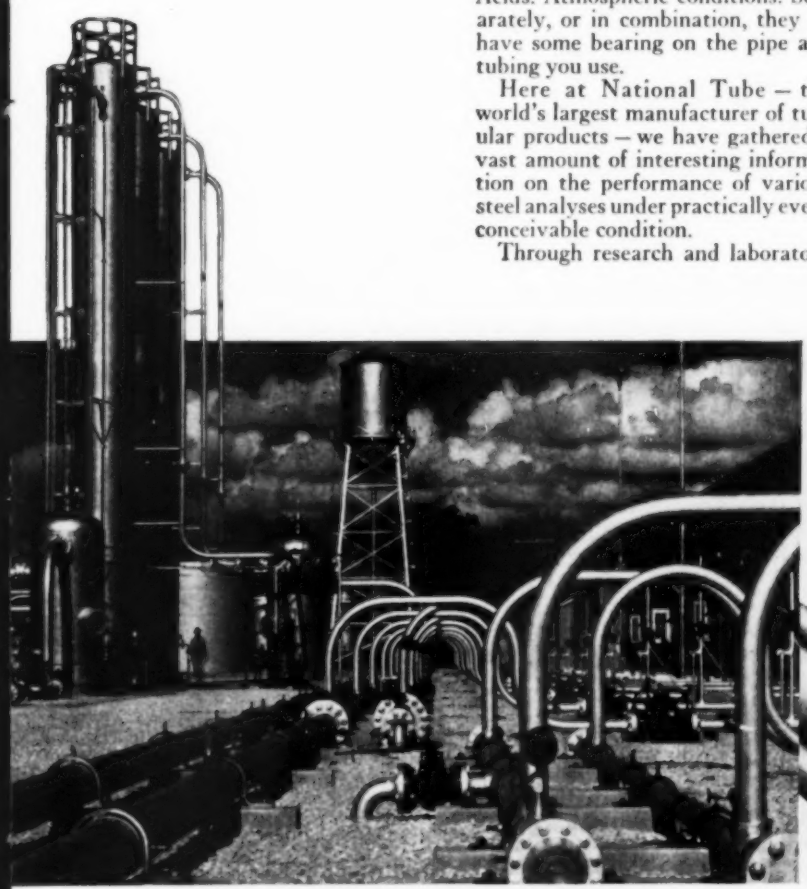

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Carbon, ½ Mo	2¼ Cr, 1 Mo	5 Cr, ½ Mo, 1½ Si
½ Cr, ½ Mo	2¼ Cr, ½ Mo, ¼ Si	5 Cr, ½ Mo, Ti
1 Cr, ½ Mo	3 Cr, 1 Mo	7 Cr, ½ Mo
1¼ Cr, ½ Mo		8 Cr, ½ Mo
		8 Cr, 1 Mo
		9 Cr, 1 Mo
		12 Cr, Al
		17 Cr
		27 Cr
		18-8
		18-8 Ti
		18-8 Cb
		18-8 Mo
		25-20

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UNITED STATES STEEL

CONSTRUCTION **BOXSCORE**: Refineries and Other Plants

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Standard (N.J.)	Hamburg, Germany	General Expan.	32,000 bbls.	$10 million	Plan	Jan., 1954		S.O.D.	Gutehoffnung-Schutte
Standard-Vacuum Ref. of South Africa	Wentworth, Durban, Union of S. Africa	Refinery	15,600 bbls.	$17 million	Under Constr.	Jan., 1954		S.O.D.	Foster Wheeler
Trent Oil Prod. Development Co.	North Shields, England	Crude Plt.	11,500 bbls.	$4.8 million	Plans Approved				
Turkish Institute of Minerals Prospecting	Southeastern, Turkey	Refinery	6,000 bbls.	$7,000,000	Projected	End 1954		Parsons	Parsons
Union Petrol Refinery Ltd.	Johannesburg, Union of South Africa	New Refinery		$20 million	Projected				
Vacuum Oil Co., Ltd.	Birkenhead, Eng.	Grease Plt.		$28 million	Under Constr.	Completing			
Vacuum Oil Co.	Coryton, Eng.	Refinery	17,000 bbls.	$30 million	Under Constr.	3rd Qtr., 1953	Texaco	Lummus	Lummus
Near East									
Anglo-Iranian	Aden	New Refinery	100,000 bbls.		Under Constr.	1954		G. Wimpey (London) Middle East Bechtel	Middle East Bechtel Staff
Arabian American Oil Company	Ras Tanura, Saudi Arabia	Lt. Str. Run Caustic Wash and Electrolic Process for Regenerating Spent Caustic	25,000 bbls.		Engineering	Dec., 1953	Amer. Dev. Co.	Aramco	
Bahrain Pet. Co.	Bahrain	Mod. of FCCU	26,000 bbls.		Under Constr.	1954		Staff, U.O.P.	Staff
Consolidated Ref., Ltd.	Haifa, Palestine	Gen. Facilities Conversion of Kellogg Comb-Top. and Crk.	35,000 bbls.		Planned			Badger Div.	
Iraq Government	Baghdad Area	Refinery	24,000 bbls.	$25.2 million	Contracted	Spring, 1954		Kellogg	Kellogg
Israeli Government	Haifa, Palestine	Petro Chem. Plt.	10 tons	$2.5 million	Under Constr.				Staff
Mediterranean Refining Co.	Sidon, Lebanon	Refinery	6,250 bbls.		Under Constr.		U.O.P.	G. S. Colley, Procon	G. S. Colley
Turkey Government	Ramandag Field	Refinery	3,000 bbls.	$5.5 million	Planning				
Far East									
Bataafsche Pet. Mij. (Shell)	Balikpapan, Borneo, East Indies	Expansion	44,000 bbls.		Under Constr.	Early, 1955			
Bataafsche Pet. Mij.	Tjepu, Java	Rebuild TEL Blending Unit & Dist. Unit			Planning				
Burmah Shell	Bombay, India	Refinery	40,000 bbls.	$47 million	Projected	1955			
*Caltex	Vizagapatam, India	Refinery	10,000 bbls.		To start in 1955				
Daikyo Oil Co.	Yokkaichi, Japan	Houdriflow	4,200 bbls.		Projected		Houdry		Houdry
Koa Oil Co., Ltd.	Marifu, Japan	Platformer	1,200 bbls.		Under Constr.	1954	U.O.P.	U.O.P.	Local
Koppers Company	India	2 Coal Hydrogenation Plts.	70,000 tons		Announced				
Maruzen Oil Co., Ltd.	Wakayama Prefecture, Japan	Cat. Crker., Dist Increase	13,000 bbls. +15,500 bbls.		Planning	Nov., 1953			
Mitsubishi Oil Co. Ltd.	Tokyo, Japan	Vacuum Distillation Unit	2,000 bbls.						
Mitsubishi Oil	Tokyo, Japan	Solvent Extraction & Dewaxing Processes					Texaco Dev.		
Nippon Petroleum Refining Co., Ltd.	Yokohama, Japan	Modern and Expansion	12,000 bbls.		Under Constr.	1955		McKee	McKee
Nippon Petroleum Refining Co., Ltd.	Kudamatsu, Japan	Platformer	1,200 bbls.		Under Constr.	1954	U.O.P.	U.O.P.	Staff
Standard-Vacuum Refin. Co. of India	Bombay, India	Refinery	25,000 bbls.	$32,500,000	Under Constr.	July, 1954		S.O.D.	Lummus
Oceania									
A. I. O. C.	Kwinana, Australia	Refinery	60,000 bbls.		Under Constr.				Kellogg, Kellogg International, Costain-John Brown
Australian Oil Refining, Ltd.	Kurnell, Australia	Refinery	22,000 bbls.		Under Constr.	Jan., 1955		Badger, Ewbank & Partners, Christiani & Nielson	Badger
Australian Shell	Clyde, New South Wales	LVI Lube Oil	250 bbls.	$620,000	Completed				
Australian Shell Oil	Geelong	Crude Dist.	25,000 bbls.	$12 million	Under Constr.	Mid 1954			
Australian Shell	Geelong, Victoria, Australia	Bitumen and Luboil Plt.		$10 million	Projected	Late 1953			
Australian Shell	Geelong, Victoria, Australia	Asphalt, Lube Sol. Extet. Plt.			Projected	Late 1953			
Australian Shell	Melbourne, Australia	New Refinery	22,000 bbls.		Under Constr.	Fall, 1953			
Australian Shell	Port Phillip Bay, Victoria	Refinery	20,000 bbls.	$9 million	Under Constr.	1954			
Caltex (Philippines, Inc.)	Batangas, P.I.	Refinery	13,000 bbls.		Under Constr.	1955		Foster Wheeler, McKee	Foster Wheeler
Standard-Vacuum Refining Co., Ltd.	Melbourne, Aust.	Refinery	20,000 bbls.	$30 million	Under Constr.	Jan., 1955		Braun, Staff	Braun

* First appearance in tabulation. † Added capacity.

NOTE: Atlantic—Atlantic Ref. Co. Austin—Austin Co. Badger Div.—Stone & Webster Engineering Co. Barnes—W. M. Barnes Co. Bechtel—Bechtel Corp. Blaw—Blaw-Knox Construction Co. Braun—C. F. Braun Co. Brown & Root—Brown & Root Construction Co. Buckner—F. J. Buckner Corp. Calif. Res.—California Research Corp. Can. Kellogg—Canadian Kellogg Co. Cat. Constr.—Catalytic Construction Co. Chemico—Chemical Construction Co. Ch. Pro.—Chemical Process, Inc. C. B. & I.—Chicago Bridge & Iron Works Company Chiyoda—Chiyoda Chemical Engineering & Construction Co., Ltd. C. & I.—Chemical & Industrial Corp. Consd. Eng.—Consolidated Engineering Company Craig—A. F. Craig & Co. D & Z—Day & Zimmerman Delta—Delta Engineering Corp. Dresser—Dresser Engineering Corp. Ebasco—Ebasco Services, Inc. E&A—Ehrhart & Arthur, Inc. Edeleanu—Edeleanu Gesellschaft M. B. H. Fish—The Fish Engineering Corp. Ferguson—H. K. Ferguson Co. Fluor—Fluor Corp. Gas Plant Constr.—Gasoline Plant Construction Corporation Graff—Graff Engineering & Equipment Grebe & Doremus—Grebe & Doremus Process Co. Gutte-Hutte—Gutte Hofnungs Hutte Hercules—Hercules Powder Co. Hudson—Hudson Engineering Corp. H.W.P.—Head Wrightson Process, Ltd. Hydrocarbon—Hydrocarbon Research Inc. Hydro M—Hydrocarbon Mineraloel G.m.b.H. Hydro E—Hydrocarbon Engineering S.A.R.L. Kaiser—Kaiser Engineers Kellogg—The M. W. Kellogg Co. Kellogg—P. A.—Kellogg Pan-American Koch—Koch Engineering Company Koppers—Koppers Co., Inc. Lummus—The Lummus Co. Macco—Macco Corp. McKee—Arthur G. McKee Co. M-C & S—Merritt-Chapman & Scott Corp. C. L. Olson P. A. HydroRes—Pan-American Hydrocarbon Research Co. Parker—Parker, Steffens & Pearce Parsons—The Ralph M. Parsons Co. Petco—Petroleum Engineering Tool Co. Phillips—Phillips Petroleum Co. Pritchard—J. H. Pritchard Co. Procon—Procon, Inc. Quaker—Quaker Valley Constructors Ref. Eng.—Refinery Engineering Company Rust—Rust Engr. Co. S & B—Singmaster & Breyer Separator-Nobel Co. Socony-Vac.—Socony-Vacuum Oil Co. Southwestern—Southwestern Constr. Co. S. O. D.—Standard Oil Development Co. Sohio—Standard Oil Co. of Ohio Stearns-Roger—Stearns-Roger Manufacturing Co. Stone & Webster—Stone & Webster Construction Co. Sunland—Sunland Refining Company Sweco—Southwestern Engineering Co. Tears—Tears Engineers Tellepsen—Tellepsen Construction Company Texaco Dev.—Texaco Development Corp. Texaco—The Texas Co. Texas Natural—Texas Natural Gasoline Corp. U.O.P.—Universal Oil Products Company J. G. White—J. G. White Eng. Corp.

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Announcing Bridgeport's New "Condenser and Heat Exchanger Tube Handbook"

For a better understanding of tube corrosion and maintenance problems

Which condenser tube alloy will give the best service life? To help solve this problem Bridgeport Brass Company has published a 156-page book which deals with the properties of available copper-base alloys for condenser tubes and their applications in the chemical, petrochemical, processing industries, power and marine fields.

Copper and copper alloy tubes are used for conveying corrosive liquids, exchanging heat, refrigeration, steam generation, reclaiming waste heat, evaporating, distilling, condensing, fractionating, extracting oil by means of solvents, etc.

Tubes carry many processing liquors, cooling waters, gases, acids, salts, bases, and organic compounds in water and other solvents. Each application requires careful study and sometimes experiments by trial in service.

Causes of Corrosion

The new book deals with corrosion problems. Much information is based on facts developed through laboratory corrosion research and field tests. Such data when correlated with actual operating experience are helpful in specifying which alloys will give best results for specific applications.

A large section of this book is devoted to corrosion from water which is probably the most widespread cause of corrosion. This subject has been covered from such angles as effects of alloy composition, water composition, pH values, soluble salts, dissolved gases, protective and nonprotective films, biofouling, oxygen concentration, impingement, foreign matter, dezincification, temperature, inhibitors, etc. Also dealt with are galvanic corrosion, causes of stress corrosion cracking, effects of vibration, and steam erosion-corrosion.

Time Saving Tables

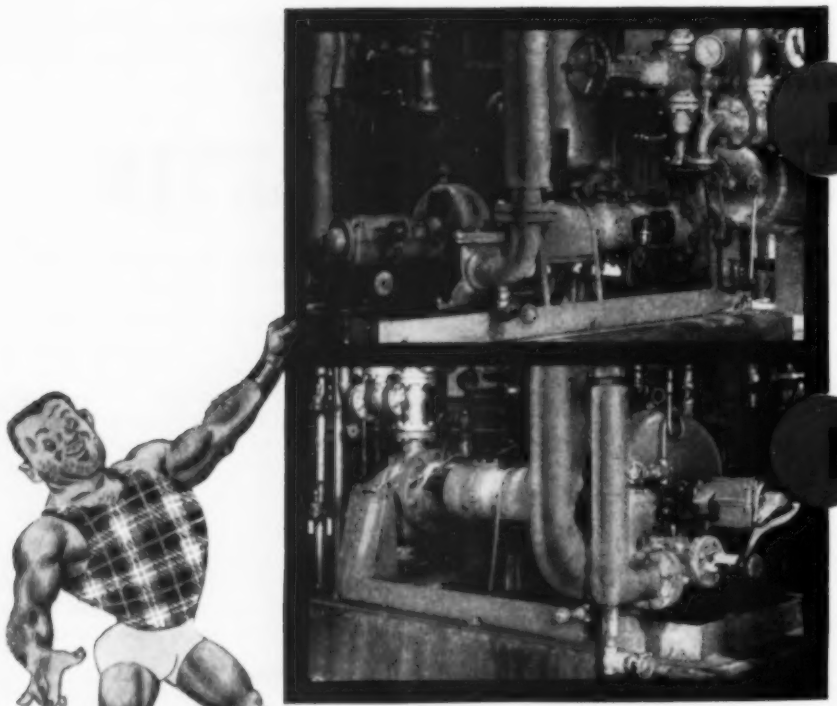
The new book carries many tables, data and formulas. It covers heat transfer rates and general specifications. Especially valuable is the comprehensive table listing in compact form the comparative properties of standard condenser tube alloys including such items as alloy composition, mechanical properties, physical constants, thermal and electrical data, fabrication properties and specification numbers.

Considerable space deals with the care, handling and storing of condenser and heat exchanger tubes; methods of installation; cleaning and removal of old tubes.

A portion of the book is devoted to various Duplex tubes combinations of ferrous and nonferrous alloys to offset the effects of two different corrosive media which may exist simultaneously on the outside and inside of the tubes. The applications of Duplex Tubing in industry are rapidly increasing.

How to Obtain a Copy

This valuable book can be of great help to engineers concerned with the selection of tubes, design, operation and maintenance of all types of condensers and heat exchanger equipment. You may obtain a copy by writing to Bridgeport Brass Company, Bridgeport 2, Connecticut, on your company stationery. If you have a corrosion problem, or require condenser and heat exchanger tubes, contact your nearest Bridgeport district office. Our Technical Service Department will be glad to help you select the correct alloy or Duplex Tubing combination which will give you the best service life. (101)



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For Your Small Jobs

Installed in a large southern refinery, this Dean Hill Type DH Steam Turbine efficiently provides all the H.P. needed for driving centrifugal process equipment.

MORE POWER!

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1,000 H.P. is available for this process pumping operation (same plant as above). Dean Hill is on the job with this powerful steam turbine.

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Small and large, Dean Hill Turbines are built to give all the power you need, at less expense. Specifically designed for operation at medium steam pressure. Since they are the single stage, double impact type, low steam consumption is a tremendous economy feature. Most key DH Turbine parts are interchangeable in all sizes of DH Turbines. Write today for full details and specifications.

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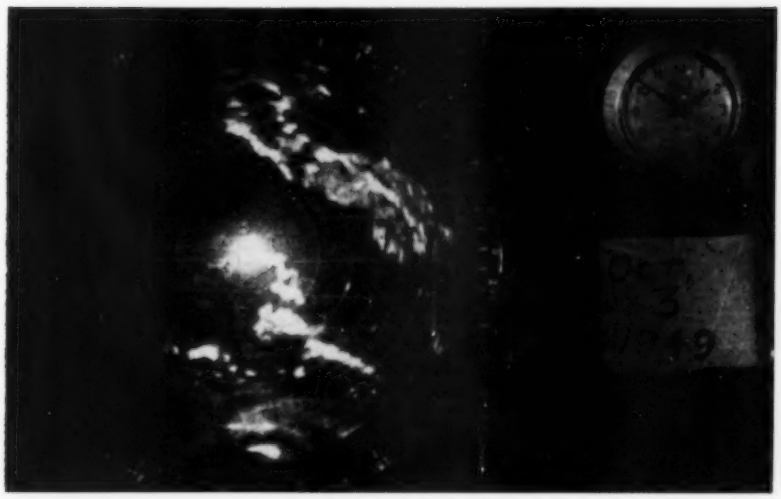

A hurricane 180 to 200 miles away as it looks on the radarscope at Dow Chemical Company, Freeport. This hurricane came directly at the plant, forcing it to shut down.

When the Big Winds Blow

Maximum plant efficiency demands knowledge of speed, intensity and direction of a hurricane.

Al Reese and Robert E. Spann, Refiner Staff

A NETWORK of radar sets like Dow's could hold its eye on almost any Gulf storm, no matter how erratic its course or how variable its forward speed. Each plant has a shutdown procedure requiring a constant number of hours, and to know at all times the whereabouts, intensity, direction and speed of a storm would permit production to continue until the big winds came within a critical radius.

Critical Area. At Dow, a storm is in a critical radius when it can reach the plants in 18 to 24 hours. At this point, the surrounding area is alerted and debris and other material that would be hazardous in a high wind are removed and some plants are shut down. Ten to 12 hours before the anticipated arrival of the big winds, the shutdown procedure starts. Additional plants are shut in and personnel moves out. The evacuation and plant shutdown is completed 2 to 4 hours before the big winds arrive.

To facilitate precautionary measures Dow has set up employe committees with assigned duties. These are Storm Warning and Communication; Plant Operation, Evacuation and Transportation; First Aid and Safety; Supplies, Preparation, Repair and Cleanup; and Community Service.

At Humble Oil & Refining Company's Baytown refinery the critical period is 24 hours, at which time the shell still batteries are shut down so they can be pumped out—a 16-hour job. The second step is to shut down the pipe stills upon eight hours' notice. Power service is cut, steam-powered water pumps are made ready, and the Mechanical department secures the gantry frames. Line crews and rigging crews are augmented during the emergency. The major concern is to have the equipment cool enough before the storm strikes so that it won't be necessary to run water for cooling to keep pressures from building up.

Part 2

Humble's plant, which was designed to withstand 125-mile winds, was damaged only in 1943, when a storm struck from the landward side, battering the cooling towers. Fungus and chemical deterioration make these units more suspectible to storm damage than any other part of the refinery.

Putting the Humble refinery back onstream illustrates the cost of shutting down an installation of such proportions. It takes 24 to 36 hours to fire up the multitude of units because many depend on feed stock from sister units. Also, some are difficult to get in balanced operation after being shut down. Following the storm of September, 1949, it required two weeks to get the entire plant running smoothly at capacity.

The general precautionary procedure used at Gulf Coast refineries is roughly typified at The Texas Company's Port Arthur plant, which uses a four-point program:

1. During the hurricane season protection levees are checked to see that they are in safe condition and of the proper elevation for plant protection.

2. All tanks during hurricane season receive unusual attention. If they are open they are made so they can be flooded to prevent being washed away, and guyed in case of a missing roof so the shell of the tank will not collapse.

3. All scaffolding on structures and buildings is made fast during the hurricane season to avoid flying objects during high winds.

4. All disturbances in the Gulf are followed closely as to their intensity and course of travel in order to allow ample time for extraordinary precautions should the plant be in the wind's path. In this case the amount of equipment to be shut down depends on the intensity of the storm. Texaco, like most companies, relies

STOP COSTLY WATER HAMMER NOW!

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Williams-Hager Flanged Silent Check Valves are the economical and dependable answer to troublesome and costly "water hammer" in all pump lines. These valves operate effectively in horizontal, vertical, upside down or angular positions—under any service or pressure condition.

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This bulletin gives complete details on the cause, effect and control of damaging "Water Hammer." Use the coupon below for prompt delivery of your copy.

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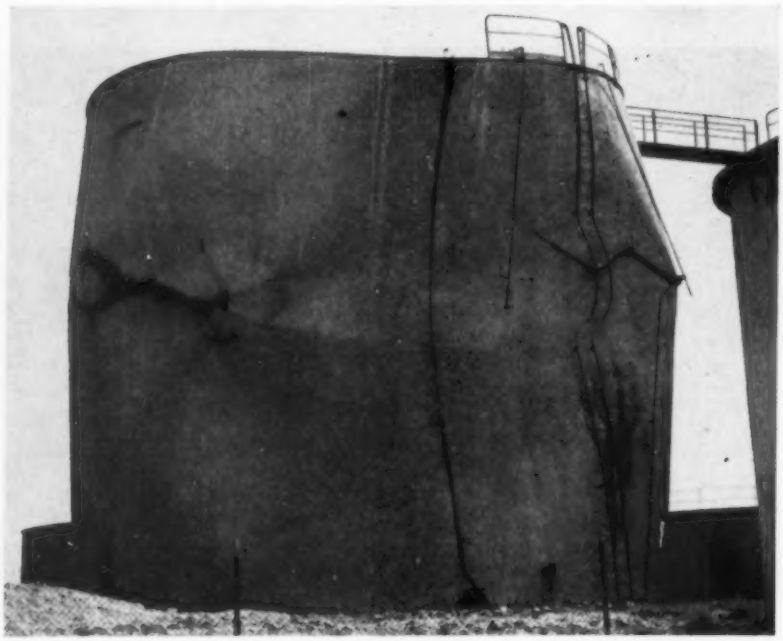

This tank was battered by a hurricane which struck Wake Island on Sept. 18, 1952.

heavily on the experience of weatherwise personnel.

Similar basic precautions are taken along the East Coast of the U. S., with some plants having unusually good protection. Among these is Socony-Vacuum Oil Company's Paulsboro, N. J., plant, which has its own weather station. The Philadelphia Weather Bureau provides reports which are circulated internally at the plant, and the Coast Guard also supplies data. If a severe storm is expected, contractors on the premises are advised to batten down the hatches. Tied-up lighters, barges and tugs are warned and the skippers stay put or cast out, as they think best. Supervisors and shift personnel are alerted. The plant works with township officials in maintaining dikes, which are necessary because the refinery is on low ground. Safety patrols watch sewers for overflows and backups. All equipment is designed to withstand 100 mph winds.

Aiding in the safety and efficiency of both onshore and offshore installations would be the Gulf Industries Weather Network, which according to one of its members is "now bogged down in Washington red tape." The network was organized in 1950 to purchase, install and maintain radio stations at Weather Bureau offices in Brownsville, Corpus Christi, Houston, Lake Charles and New Orleans. These stations would be utilized solely by the Weather Bureau for:

- Backup communications between the Weather Bureau offices at times when the existing land line communications failed or became overloaded.
- Disseminating information regarding unusual weather conditions during critical situations.
- Gathering vital information and data regarding unusual weather conditions.

Organizers of the network recognized that "one very serious problem encountered during the war years and which is very apparent at the present time is that of getting maximum output . . . and the most logical approach to this is to prevent any shutdown that can possibly be avoided. Plants using involved processes require relatively long periods for shutting down and starting up, with the attendant loss in output. Shutdowns that do not allow sufficient time for the proper reduction of the high temperatures and pressures subject the

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Tough, strong, ENDURO Stainless Steel can be a big factor in keeping your equipment operating . . . profitably. And one of the big reasons is its high resistance to heat and corrosion.

ENDURO maintains its great strength even under prolonged exposure to scorching temperatures. Sub-zero ones, too. Its resistance to corrosion is high, as well as to actions of most acids and alkalies. And its hard, smooth surface discourages coking and fouling —washes off easily and quickly during off-stream periods.

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Whether you're planning expanded plant facilities . . . or new ones . . . it will profit you to get all the facts about ENDURO. Several analyses of these Heat-Resisting Stainless Steels are currently available. Write to:

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You won't have to wait two years for a Cat Cracker if you contract with TRECO. REFINERY ENGINEERING Company has consistently built Cat Crackers and had them "on stream" in one year or less. Want speed? *Give us a year and we'll give you a Cat Cracker* . . . the gain in time saved can pay half the cost of the plant. When you contract for a Cat Cracker you want quality workmanship and speed of construction at the right price. You get all these when you deal with REFINERY ENGINEERING Company. TRECO has the manpower, the equipment and the "know how" to rebuild your old plant or to build you a complete new refinery in the shortest possible time. Contact your nearest TRECO office for more information.

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plant and personnel to hazards that might possibly prove disastrous."

Among members of the network are Carbide and Carbon Corporation, Texas City; Celanese Corporation of America, Bishop, Texas; Central Power and Light Company, Corpus Christi; Cities Service Refining Corporation, Lake Charles; Dow Chemical; E. I. du Pont de Nemours and Company, Orange, Texas; Monsanto Chemical Company, Texas City; Pan American Refining Corporation, Texas City; Southern Alkali Corporation, Corpus Christi; Taylor Refining Company, Corpus Christi; Mathieson Chemical Corporation, Lake Charles; Aluminum Corporation of America, Port Lavaca, Texas, and Copano Research Foundation, Victoria.

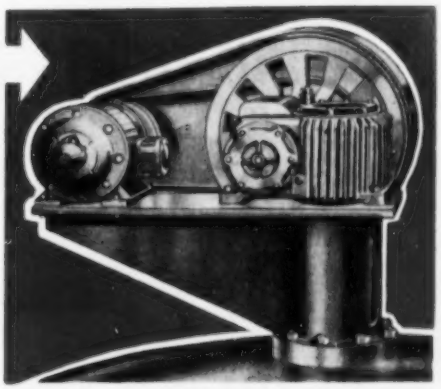
What Others Do. Elsewhere around the globe storm precautions are generally fewer. In Mexico, a blind spot in the Gulf radar chain, the public relations department of Pemex reported that "no problem exists and no specific system has been set up because there is no need for it." It was added that "Pemex does have its own extensive radio network through which warning and instructions could be sent should the occasion ever arise, and the spokesman for Pemex emphasizes that if an alerting system were necessary, it would have been set up long ago. . ."

Cuba is alert to the storm threat. Two observatories observe regular contact with the meteorological station on the island of Grand Caiman, south of Cuba, and with the Weather Bureau in Miami. When a storm approaches, the observatories issue three bulletins each day to radio stations. Most dangerous to Cuba are the storms which originate in the vicinity of Swan Island, near Grand Caiman in the Caribbean. However, these big winds strike most often at Cuba's three western provinces, where oil activity is slight. The only major operator now on the island is engaged along the north coast of the two eastern provinces, where there is less danger of weather disturbances.

Oil companies in Eastern Venezuela, which is fairly free of tropical storms, depend on the local government weather bureaus. Western Venezuela has a particularly vicious prob-

Now you can Change Speed while Mixer is in motion

"International" TYPE "LRV" MIXER

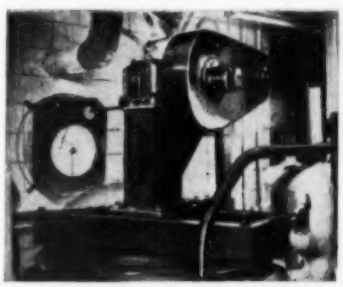


Here is a brand New Design, Variable-Speed Agitator Driving Unit—selling at a really down to earth, rock bottom price.

The speed of this unit can be changed while in motion. The capital investment for such a profitable plant improvement is relatively small.

Speed variance as high as 5 to 1 (single speed motor) with any desired speed within the above speed change range. When these units are equipped with vari-speed motor instead of the standard single speed motor an almost infinite range of speeds can be attained in a few seconds.

Speed change accomplished by simply rotating speed change knob. No gears or belts to change.



"International" Type LRV Mixer

Above photo shows installation in plant where it is desirable to be able to change shaft speed while Mixer is in full operation.

NO WORK STOPPAGE WHILE CHANGING SPEED—NO GEARS OR BELTS TO CHANGE—NO TIME LOST IN GETTING PROPER SHAFT SPEED FOR BEST RESULTS . . .

"International" Simplified Designs and standardized production Guarantee you advantages of the most expensive equipment at much lower prices.

These Mixers are adaptable to viscosity or material change while batch is being mixed; particularly useful where various viscosity materials may be mixed in the same vessel.

Units can be readily changed from one vessel to another. Mixers are package units aligned and assembled in our factory—ready to mount on your vessel and ready to operate. Mixers are designed for closed or open vessel—"LRV" for closed—"LRVA" for open tanks.

Let our Engineering Department show you, without obligation, how you can now make important equipment improvements with minimum outlay—REMEMBER, International Processing Equipment must be satisfactory or your money back.

INTERNATIONAL TYPE "LRB" MIXER

(Illustrated Below)

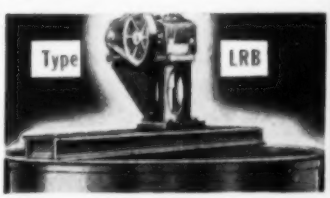
For Refinery applications where Speed need not be changed while Mixer is in operation . . .

Type "LRB" Speed changes are obtained by means of sheave substitution with standard stock taper hubs and adjustment of belt tension which requires only a few minutes of operator's time.

20 A.G.M.A. speeds from 420 rpm down to 9 rpm are available and each set up is interchangeable over an approximate 3½ to 1 speed range.

Mixers are process engineered—factory assembled—ready to operate when uncrated—and at rock bottom low cost. Arranged for closed or open tanks.

Bulletins and full information on request.



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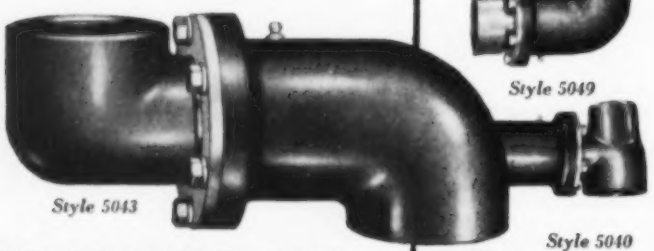

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BARCO'S new, attractively priced, all-steel ball bearing *Swing Joints* are designed specifically for refinery *service* on loading or unloading lines handling gasoline, oil, lube oil, LP gas, petro-chemicals, and other fluids.

MANY STYLES—The Barco line is complete with single swing, double swing, and counterbalance styles to meet every need! Sizes 2", 2½", 3", 4".

BALL BEARING AND O-RING EQUIPPED—In Barco Swing Joints, the ball bearings do not fall out when joints are taken apart! Long bearing provides adequate pipe support. *Special O-ring seal eliminates frequent gasket replacement and insures leakproof service* over wide temperature range, −40° F. to +225° F.

SIMPLE CONSTRUCTION—Joints can be disassembled for inspection without disconnecting piping. O-rings are easily renewable in the field.

ENGINEERING RECOMMENDATION—Barco will be glad to give you detailed recommendations on joints to use and suggested arrangements for complete loading and unloading assemblies.

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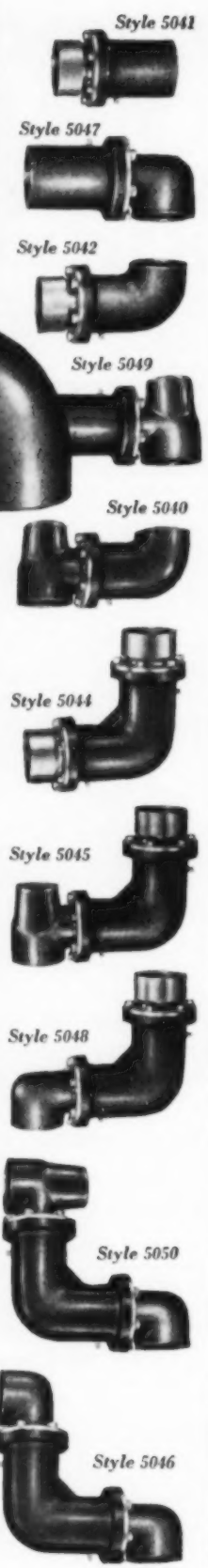


As **Management** Sees It . . .

lem in the "chubascos," very heavy rains accompanied by strong winds of short duration. Since a characteristic of the chubasco is the suddenness with which it appears, little can be done about it.

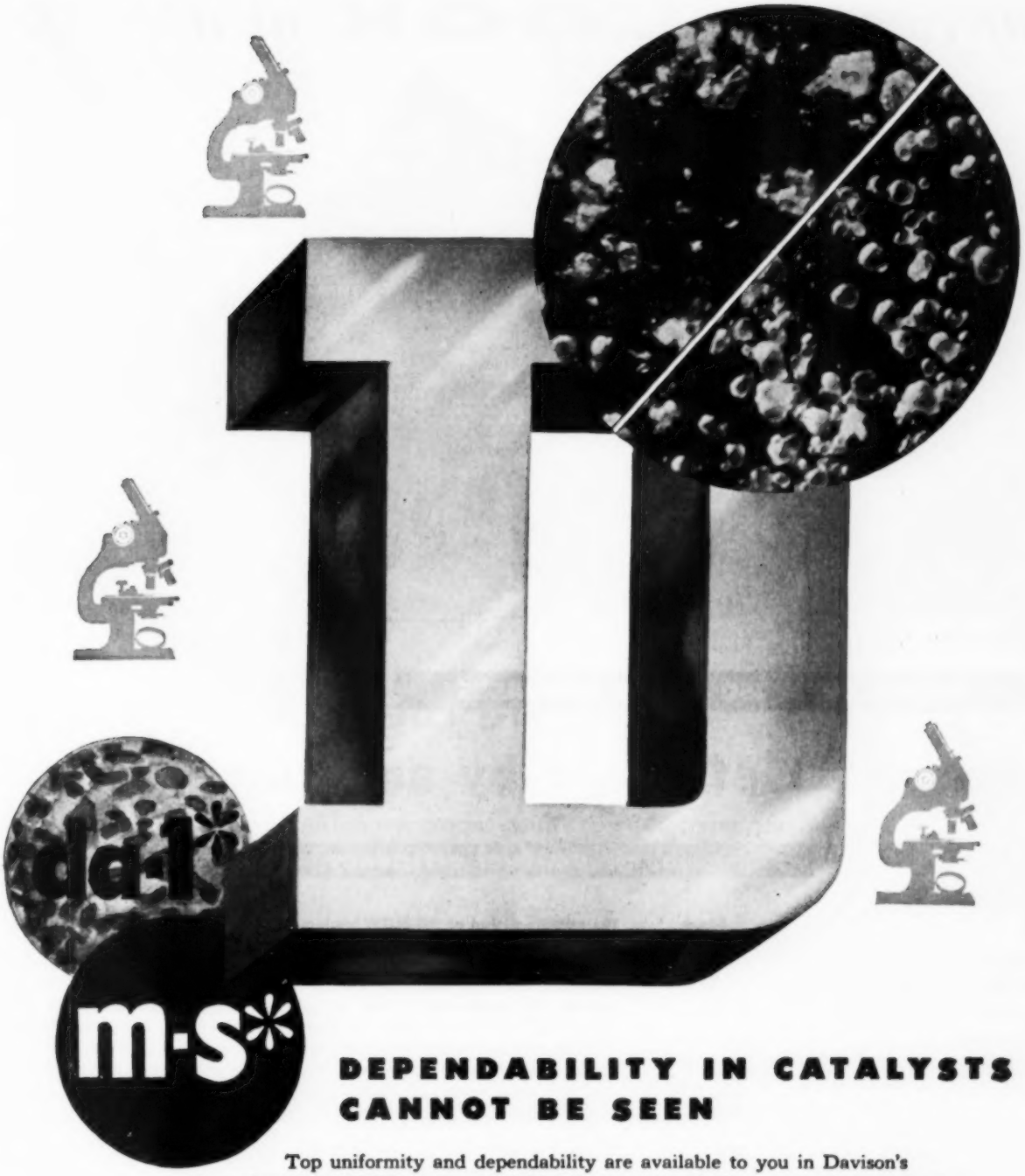
Trinidad, which is approximately 200 miles south of the hurricane zone, has had only one hurricane within living memory. That was in 1937. The chance of recurrence is considered so slight that no special storm precautions are taken. The island has a meteorological office which would alert the populace in any emergency.

Western Canada's weather alerting system is similar in many respects to that in the U. S. Mid-Continent. Storm warnings are issued when necessary by the Dominion meteorological service through local weather units, which release warnings over commercial radio stations. Most companies maintain short-wave radio equipment, with headquarters in Edmonton or Calgary, to warn men afield, and several firms have installed telephones in company cars. Planes and radar are not used, and few companies have formal programs for shutdowns.

Oil operators in the Pacific depend heavily on information received by radio from U. S. Army, Air Force and Navy bases.

The primary responsibility for safeguarding U. S. government oil facilities abroad rests with the local post, camp, station or unit commander. This responsibility, frequently spelled out in detail by higher headquarters, includes the establishment of appropriate measures for the protection of petroleum supplies at the station, storage facilities, handling equipment, etc. Precautions to be taken necessarily vary with the type, nature and extent of each operation. Details are usually determined by the petroleum officer in charge.

Data concerning tropical storms, typhoons, tidal waves and similar hazards are passed throughout affected areas by the Air Weather Service of the Air Force. Based on these warnings, local commanders can take appropriate action to secure their installations against impending storms.



DEPENDABILITY IN CATALYSTS CANNOT BE SEEN

Top uniformity and dependability are available to you in Davison's microspheroidal (M-S*) or ground (DA-1*) synthetic fluid-type cracking catalysts. The accompanying photomicrographs show the physical characteristics of the DA-1 and new M-S catalysts produced in Davison's Cincinnati plant. Uniform physical and catalytic characteristics result from Davison's modern facilities and years of technical experience and research. Experienced Davison Field Service Engineers—complete laboratory facilities—are all part of Davison Dependability—Dependability with the big "D".

*T.M.T.D.C.C.

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Baltimore 3, Maryland

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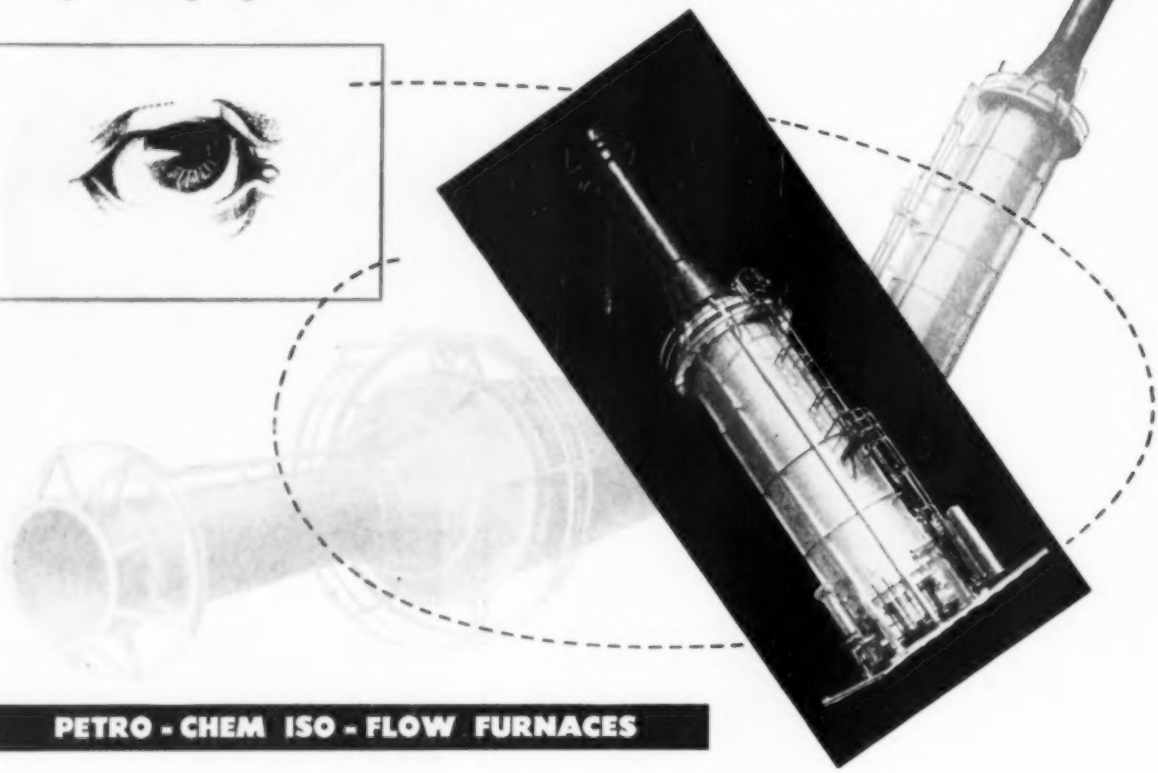
anyway you LOOK *at it!*



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maximum fuel efficiency

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The generic design of ISO-FLOW heaters, including the reradiating cone, gives excellent heat distribution, eliminating localized overheating. Further, all walls are protected by tubes which create low wall temperatures. The walls have high insulating characteristics which create minimum outside shell temperatures, and, hence, extremely low radiation. With a radiation loss of under 2%, more heat is absorbed by the fluid being heated, resulting in higher efficiency for any type of Iso-Flow design. Since Petro-Chem has a wide variety of convection sections, all heaters can be designed for optimum fuel efficiency or for maximum fuel efficiency where the price of fuel and other economic considerations justify.

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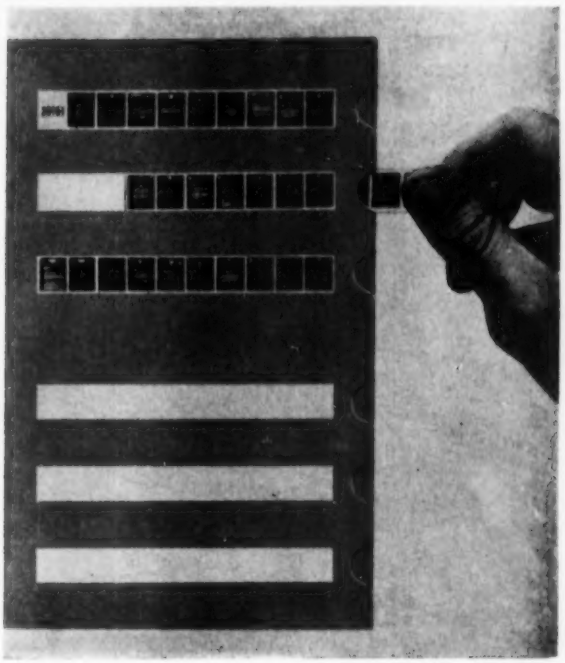


. . . . it's that quick

Microfilming Field Broadens

The camera is no longer merely a space saver. It's now an important tool in a wide range of office operations and record-keeping methods.

Edward T. Freel,
Remington Rand, Inc., New York City

ELEVEN OF the newest dual-lens microfilming cameras are doing a variety of record processing, filing and record retention jobs for a major Canadian oil company. The cameras are being used to produce current active records and for record filing and space-saving operations—from the producing and processing to the distribution and retailing levels.

Today's microfilming machines can

- Photograph most documents faster than operators can feed them.
- Count and stack the records.
- Provide their own identifying leaders and trailers.
- Make two identical copies in a single operation.
- Copy two sides at once.
- Select the right amount of film needed to photograph each document.
- Warn the operator when the film supply is exhausted.
- Stop automatically at first sign of trouble.

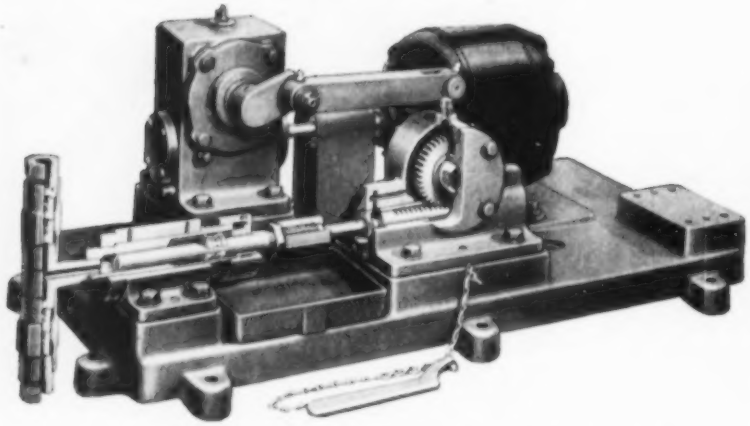
Some of the camera-handled paperwork procedures are basic elements of new systems developed for the oil industry; some are variations on high-speed, work-saving techniques common to airlines, railroads and interstate bus companies; others are adaptations of personnel record operations and of credit and invoicing control procedures familiar to many industries and to wholesale and retail outlets.

The microfilming camera—with its newly-expanded capacities for multiple filmings in a single operation—has gone far beyond earlier concepts of its functions and scope. It no longer is limited to saving filing and storage space and protecting valuable documents and records by utilization of the 8mm or 16 mm film as an off-the-scene storage container of legally acceptable facsimilies. It is now an increasingly important tool in a wide range of office operations and record-keeping methods.

New indexing and filing systems, such as one which employs the visible control advantages of index cards, are substantially expanding its range as a personnel office machine and for other procedures in which related records are maintained in convenient and extremely compact form.

Problems Mount. With oil companies constantly working to develop by-products and expanding their ranges of activity in the distribution and retailing fields, with many of them handling more extensive lines

For precisely controlled metering and proportioning of small volume flows...



...the HILLS-McCANNA "U" Type Proportioning Pump

• The Hills-McCanna "U" Type Pump is designed to continuously meter and proportion small flows of the order of 0.10 to 24 gallons per hour per feed. Its accuracy and reliability suit it for research, pilot plant operation and full scale processing alike. The "U" type pump is suitable for batch or continuous operations.

Typical examples of "U" type pump applications include:

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• Continuous injection of internal phosphate treatment and sodium sulphite oxygen scavenging in boiler plant water treatment.

• Injection of gasoline gum inhibitors into finished gasoline.

• Proportioning low molecular weight polymers and catalyst solution in resin research.

The new "U" Pump Catalog, UP-52, gives full information on the "U" type pump plus extensive application data including specific service recommendations for handling over 300 substances. Write for your copy, today. HILLS-McCANNA CO., 2441 W. Nelson St., Chicago 18, Ill.

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of accessories through their distributors and service stations, and with personnel increasing, problems of record processing and of filing and storage continue to mount.

Charge accounts at the retail level and greater credit handling at the wholesale distribution point create masses of additional records. Many companies are turning to cycle billing methods to handle this vast paperwork load with a minimum of disruption of established accounting, bookkeeping and credit department routines. Microfilming cuts detail work in cycle billing by doing away with the need for copying charge slips or preparing detailed descriptive invoices and statements.

In the case of the Canadian oil operations cited above, 9 of the 11 microfilming cameras are used in this active record preparation work of cycle billing. Only 2 of the 11 cameras are used at the company's home offices, for filing on film as a means of retaining various documents in convenient space-saving form.

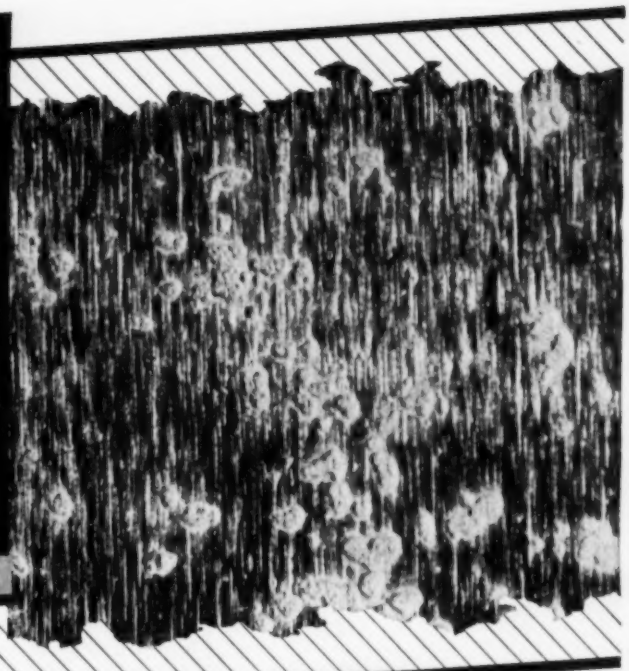
The other nine microfilming machines are part of the standard billing-credit and collection systems set up in nine key distribution centers. Here, they lead to faster handling of the masses of detailed credits and charges and, in billing operations alone, they effect savings running from 10 percent per thousand items (or charges) to upward of 15 percent per thousand.

Because of its space saving capacities (in ratios up to 200-to-1), the microfilming method has become increasingly familiar to those charged with the retention and protection of records and documents which must be kept for long periods or which, because of their value, are recorded in facsimilie copies for extra protection.

By its very nature, the oil industry has special and extensive record-keeping problems. From initial steps of locating possible oil bearing properties to drilling and transporting the crude, there are records which must be retained indefinitely, such as leases, seismograph charts, royalty arrangements and payments, etc.

Records Grow. In processing and research and development programs

How To STOP WATER-SIDE CORROSION, PITTING and TUBERCULATION



Corrosion, pitting and tuberculation are problems which all too often plague engineers. In addition to running up replacement costs, these conditions can cause lengthy and unscheduled down-time of important plant equipment. But something can be done about these problems *now*, thanks to the Dianodic* Method developed by Betz Engineers.

For instance, a Southwestern natural gasoline plant employed as make-up for its circulating cooling water system a well water of high alkalinity. Not only was chemical attack of the tower severe, but in addition, aggravated corrosion was encountered on the heads, sheets and baffle plates of the shell and tube exchangers. Heavy tuberculation and pitting was evident.

Betz Engineers recommended the new Dianodic Method of corrosion inhibition. Upon the application of this control method, chemical attack of the cooling tower wood was stopped, and the system gradually cleaned itself of the accumulated corrosion products. Plugging troubles were eliminated. A "before and after" corrosion study with test specimens showed reduction of average penetration from 0.03 inches per year to 0.002 inches per year. Maximum pit depths were reduced to less than 1/25 the previous rate.

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The Dianodic Method is a system of combining two anodic inhibitors in such a way as to effectively eliminate pitting and tuberculation, and at the same time provide protection against general corrosion and scale. It is just one part of the Betz *Specialized* Water Conditioning Service for all types of water problems. Why not call in a Betz Engineer and have him tell you how Betz can help you? You'll save yourself time, money, and trouble.

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For complete information on the Dianodic Method write today for Betz Technical Paper No. 125.

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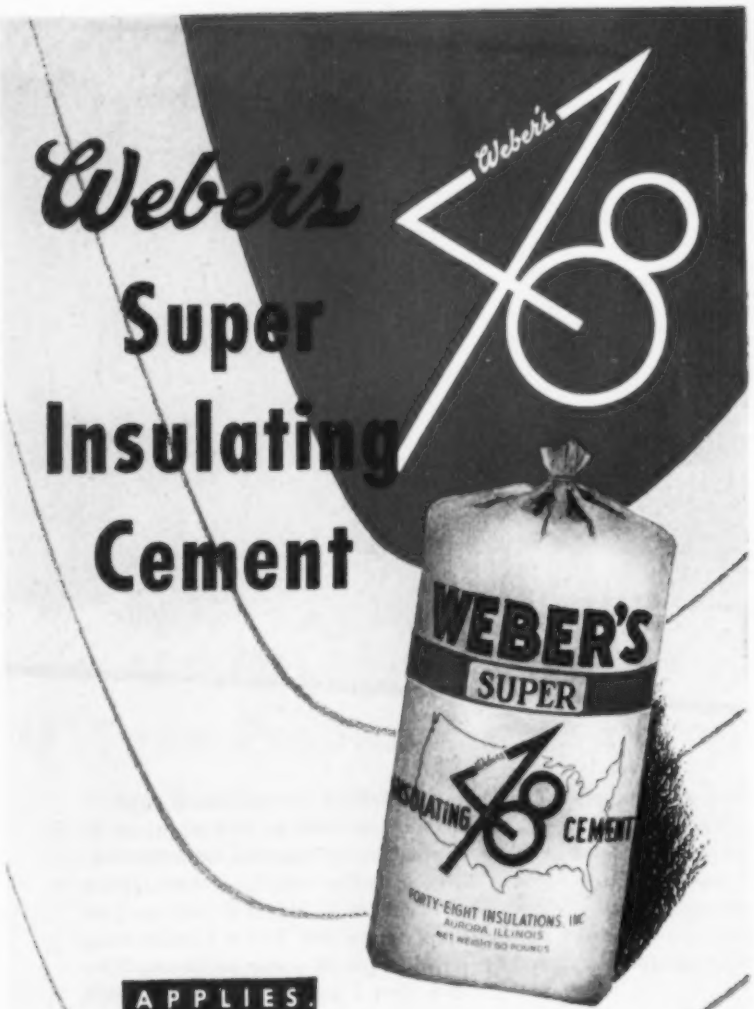
CONSULTANTS ON ALL WATER PROBLEMS



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As **Management** Sees It . . .

there are tremendous expansions of facilities, with all of the attendant expansions of records. Finally, as there is more and more activity in distribution and in retailing—of oil products, by-products and related accessories—there are still more records to be created, maintained and, in many instances, retained for varying periods.

Recent improvements in microfilming cameras have extended their range as an integral piece of office equipment in a number of ways.

For quite some time they were considered to be most practical for small and medium-sized documents and records, such as the 8½ x 11-inch and smaller correspondence, and for agreements and other papers of the size generally used for legal briefs and insurance policies. Today's microfilm camera can copy virtually any record, regardless of size or condition, reducing to a tiny fraction of their original size such cumbersome items as charts, plans, property descriptions and the like.

A significant recent development is the dual lens camera, which records exactly the images on both sides of a record in one operation, thus cutting such copying work in half.

Chief among the new developments in microfilm record housing is a card-and-index system which, by the insertion of strips of film in narrow die-cut slots of a card, provides folder-type filing for records in frequent or constant use. As many as 60 letter-size documents can be filed on a single 5-inch x 8-inch card.

This arrangement is particularly effective where it is desirable to segregate from a few to several hundred records on a single subject or related group. In this system, which is finding increasing favor for multiple-record personnel files, indexing is done either on a visible margin of the card (arranged on panels or slides and overlapping) or on the film, or both.

Where indexing is on the film strips, such as by name, number, title, date, or subject, it is done by filming identifying "targets." These can be read without the aid of an enlarging

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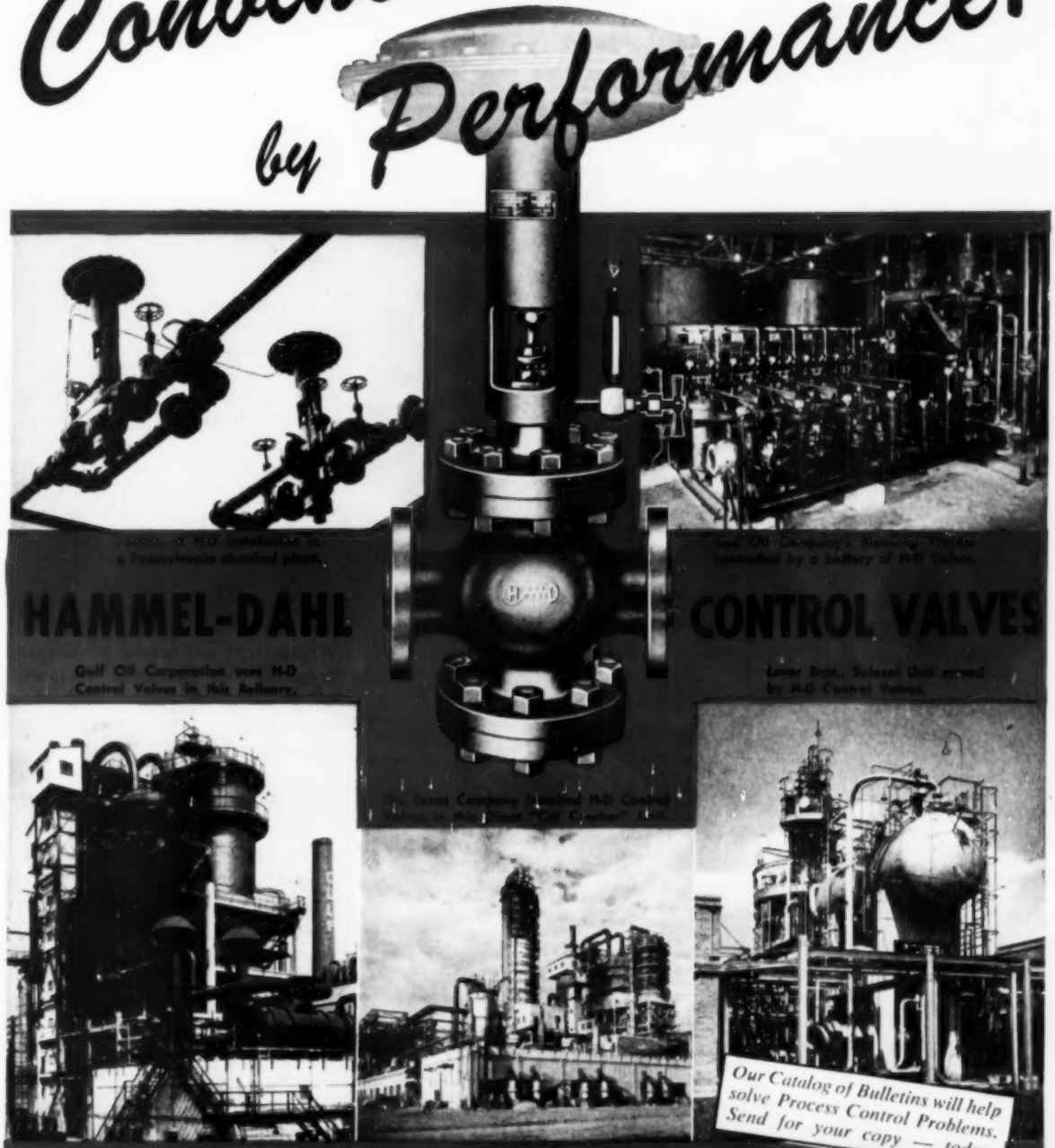
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As **Management** Sees It . . .

reader. Once the desired group of records is selected by means of this or the visible card indexing, a full-size or larger copy is thrown on the reader screen simply by inserting the card under the lens to the proper image position. Cards can be tabbed, color coded, etc., for fast reference.

Cards are cut so as to permit the slipping of individual filmed images or strips into one or more slots. Cards range in size from 2½ x 3 inches to 11 x 14 inches. New records can be added and inactive ones pulled at any time.

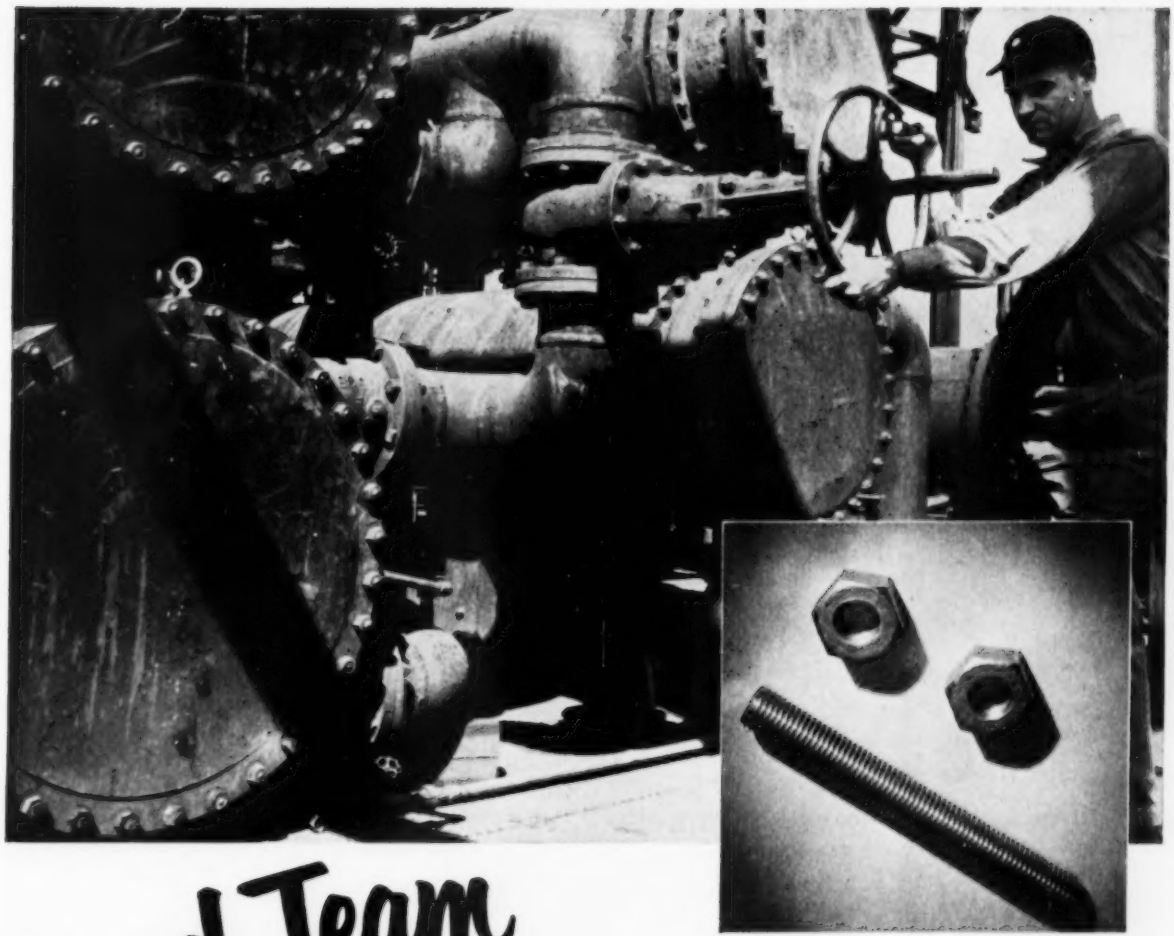
Space Saved. Although the space-saving potentials in this form of filing on film do not equal the ratios where the records are on 100-foot reels of film, the differential is still tremendous. For example, the paper content of an ordinary file drawer is 3000 to 4000 letters. The same drawer will hold more than 250,000 letter-size records on films inserted in the cards.

Because of operating simplicity and absence of need for special equipment, hookups or training, there is little or no problem involved in setting up a microfilming program. Where there are special problems of preparing old records or documents for a retention program and where their nature or number would disrupt work on current office routines, major suppliers provide trained crews to handle such special loads.

Once the system is in operation, often with only a little on-the-job training, the only requirements to convert any office staff members into microfilm operators is a reasonable degree of dexterity and interest in the work.

Where there are extensive distribution or retailing paperwork problems of handling credits and invoicing, microfilming of charge slips eliminates need for copying, proofreading or the preparation of descriptive invoices. In most instances, charge slips are fed through the camera and then attached to the invoice or statement sent the customer. The film is retained as the company record. And where procedures call for charge records at the distribution point and at the home office, a single processing

■ SEE MICROFILMING, PAGE 227



Good Team for High-Temperature Bolting

Here's a high-temperature, high-pressure fastener team that you can use with confidence. It consists of the Bethlehem Continuous-Thread Stud and two Bethlehem Quenched Nuts. It resists premature failure caused by high temperatures and pressures; it is economical, too, because it minimizes down-time.

With the Bethlehem Continuous-Thread Stud, stress-concentrations are unlikely to occur. This is because the stud has no point of thread-runout. Instead of converging at any one point to cause premature failure, stresses are distributed along the full working length of the stud. The stud is manufactured from carbon or alloy steel, and is furnished plain or heat-treated.

The Bethlehem Quenched Nut is made from .40-to-.50 carbon steel by forging and extruding hot steel in a forming die, then quenching and tempering. This method of manufacture arms the nut with sufficient stamina to develop the full strength of any stud or bolt.

If you have any questions about the use of fasteners in high-temperature, high-pressure service, put them up to Bethlehem. A letter addressed to the nearest Bethlehem office will bring a representative to your desk promptly.

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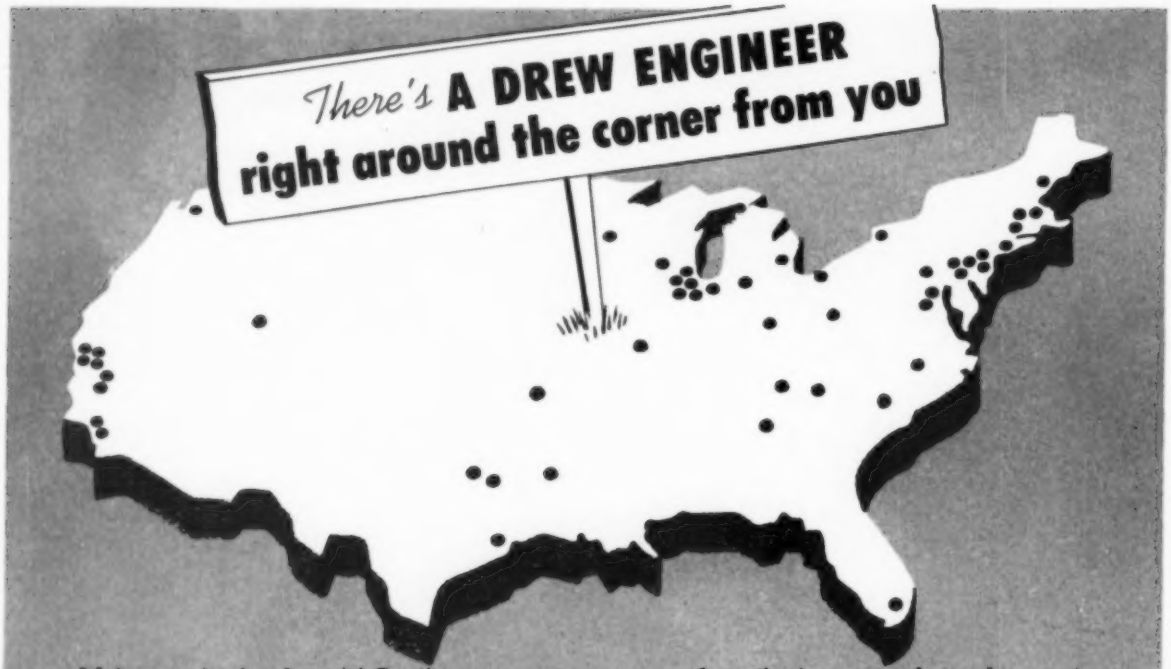

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As **MANAGEMENT** Sees It . . .

Editor's Note: *It is axiomatic in the petroleum industry that accidents seldom happen to experienced workers on hazardous jobs. It is the easy routine task that invites carelessness and causes injuries. This is the first of a series of pictorial safety messages taken directly from the accident experiences of refineries and natural gasoline plants. Only the names of the persons and companies involved will be omitted. Clip them. Put them on your bulletin board. Drive home the warning that IT'S EASY TO GET HURT.*

The Accident: Operators were having difficulty in maintaining suction on a pump being used to transfer caustic solution from drums into a small tank. Several times they removed a plug on the pump to insert liquid for priming purposes. Finally, one man removed his goggles, which had become clouded, and unscrewed the plug again. Priming liquid was added, the air turned on, and the chemical sprayed into the operator's face. He refused to go under a nearby water shower, insisting he be taken to the hospital.

Recommendation: Severity of the burn would have been minimized by the water shower. The injury would have been avoided by (1) stopping the work while the goggles were cleaned; or (2) by previously applying a no-fog material to the lenses; or (3) by using a chemical hood.

Microfilming

■ CONTINUED FROM PAGE 224

with a dual-lens camera serves to provide both records.

A color stat or voltage control automatically regulates the extent of exposure required, so that the operator's job is limited to switching the machine on and off and feeding the documents.

Where a full-size or enlarged copy of a microfilmed record is needed, it can be reproduced quickly and economically with the reader or viewer unit.

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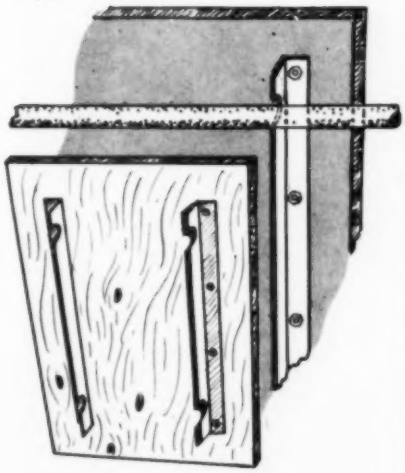
How to **DO** It



Durable Scaffolding **Effects Big Savings**

The portable scaffolding platform shown in the drawing can be reused many times, saving both carpenter man-hours and materials.

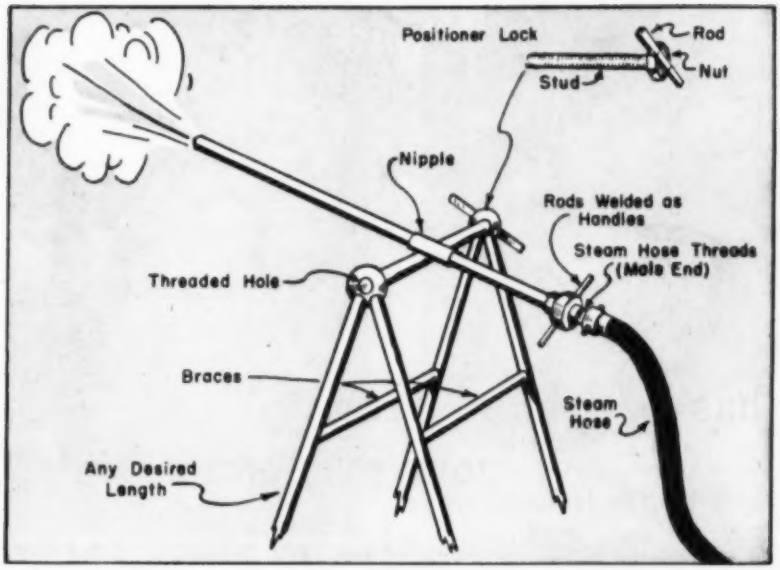
Most refiners erect temporary scaffolding and platforms for turnarounds and other repair jobs. This usually requires carpenter preparation for each job and scaffolding and platforms which must be subsequently torn down. This idea suggests that the scaffolding be made of durable material such as steel pipe and that the platform be constructed as follows.

To the desired size of one-inch plywood, metal guide bars are bolted. The bars are drilled to permit passage of the scaffolding rods. The outfit is then ready for easy assembly and breakdown for many different jobs.

J. E. Brooks, Wood River, Ill., submitted this idea.

How to Do It Ideas Are Worth Money

Enter Petroleum Refiner's How to Do It Contest and turn ideas into cash. Best idea submitted in 1953 wins $100; second place gets $50, and third place, $25. Send your ideas with photos or sketches to Editor, Petroleum Refiner, P. O. Box 2608, Houston, Texas.



Positioner **Hits Hot Spots with Water**

The device shown in the accompaning drawing has found ready application in directing steam and water at trouble spots with maximum efficiency. Dubbed by the originator as a "universal hose positioner," the device is novel in the unusual design of its pivot arrangement.

The supporting stand is made of one-inch pipe, with the legs suitably braced.

A rod welded to a nut which fits the end of the stud serves as a lock. The main spray is mounted across the supporting stand by attaching to a conventional pipe nipple. The same type of rod-and-nut lock is used to attach the male end of the steam hose to the spray.

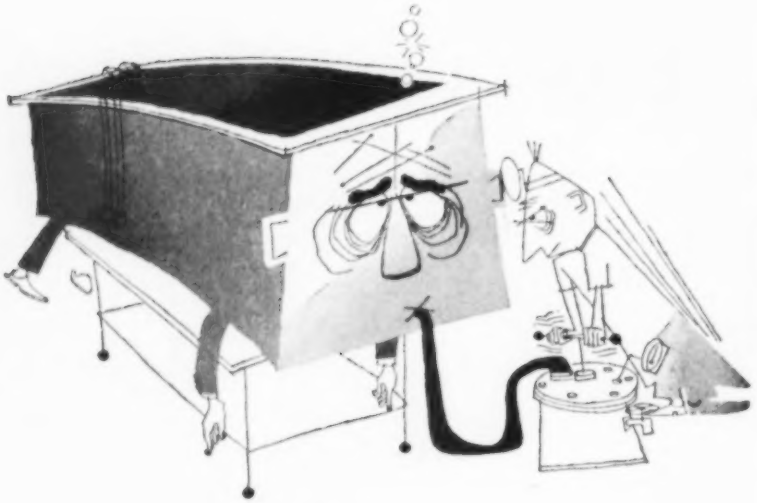
The device has been widely used for many different purposes, including: spraying a well-directed stream of steam, directing water against an over-heated condenser or vessel, and for general fire-protection purposes. This item was contributed by J. E. Brooks, General Delivery, Wood River, Ill.

Exhauster **Reduces Heat and Smoke**

An on-his-toes welder invented a device that made his job both safer and more comfortable. The photograph at right pictures the "exhauster" which removes both smoke and heat. Made of discarded and essentially worthless materials, the ingenious device can be easily duplicated by any interested refinery.

The starting point is our old standby—the discarded 55-gallon drum. Mounted inside is a small (say 1000 CFM) fan. The fan is rigidly mounted on welded supports. The fan draws the air away from the welder, thus keeping his surroundings free of smoke and heat. The supporting brackets for the exhauster are so designed that it can be lowered or elevated to any desired position, thus insuring maximum efficiency with the least possible interference with the welder's work.

Joe Tarin, Republic Oil Refining Company, reported this item.



has coil-itis* cramped your production flow?

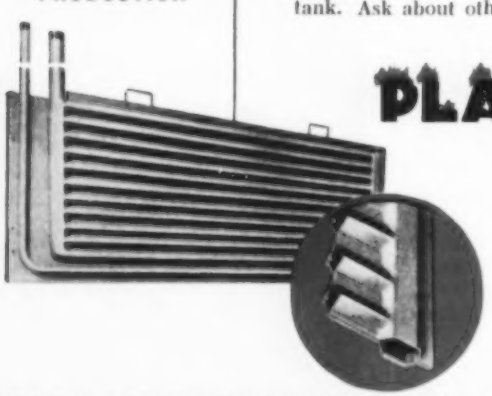
It's a waste of costly time to pump out the solution every time your process heating and cooling tanks get indigestion due to pipe coil troubles. You can save this cost and eliminate production bottlenecks by replacing the pipe coils with Platecoils. Platecoils can be removed and replaced **without dumping the solution**. They simplify maintenance and save hours of downtime. They heat or cool 50% faster and take 50% less space in the tank. As revolutionary as the new wonder drugs, Platecoils cure production troubles involving heat transfer . . . and give profits a shot in the arm.

Write for bulletin P78 today!

PLATECOILS SAVE 50% IN HEAT TRANSFER COSTS

PLATECOILS TRIPLE PRODUCTION

At Continental Motors Corp., 3 crankcase sections can be cleaned at one time when Platecoils are used while only one crank case can be cleaned with pipecoils in the tank. Ask about other case histories.



PLATECOIL

REPLACES PIPE COILS

*

Coil-itis — Diagnosed as tank heating and cooling problems. Platecoils — the prescription for solving pipe coil problems.

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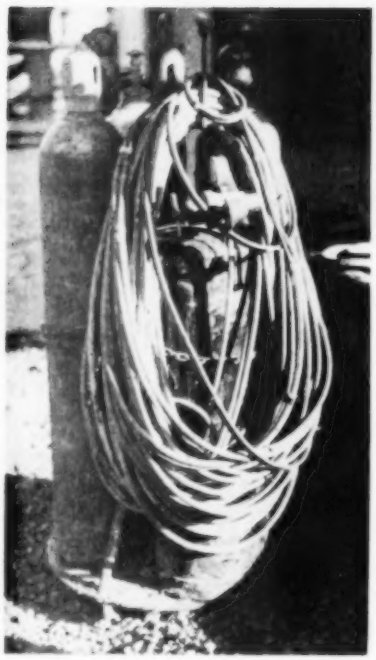
How to **DO** It . . .



Simple Welding Rig
Makes Moving Easy

The compact, "unitized" welding rig shown in the above photograph was devised to insure adequate supplies of oxygen and acetylene for the welder without frequent shut-downs to hook up another cylinder.

Its construction was prompted by the necessarily long periods of welding accompanying turnarounds on cat crackers where it is usually necessary to remove eroded piping in standpipes and carrying lines.

A circular sheet of heavy steel was obtained with a surface area large enough to support three oxygen cylinders and one acetylene drum.

In the center of this base plate was welded a one-inch rod standing in a vertical position and topped with a loop to attach a chain for hoisting. The lower part of the standard was reinforced with four diagonal braces for stability.

At the junction of the diagonal braces with the vertical standard, loops were attached to thread a chain to confine the cylinders. Extending from one side of the standard is a smoothly finished hook upon which the long hoses are hung when the welder has completed the job.

In ordinary operation, this unit remains upon the ground, but, because of the standard in the center, the entire group of cylinders can easily be hoisted to any level within the processing structure.

This very inexpensive device can be manufactured from material in your scrap pile.

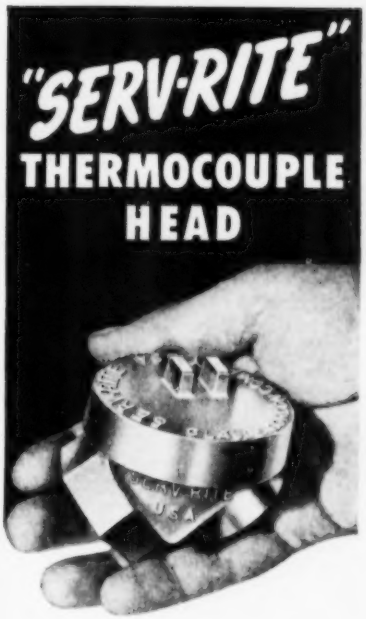
Plastic Bags **Keep Equipment Sanitary**

Economics clearly point up the need for reuse of safety equipment such as goggles and hard hats. Every plant and construction firm is faced with the problem of temporary users of such equipment who require it for only a short period. Good sanitation practice dictates that the equipment either be discarded or suitably treated to render it safe for the next user. Since the cost of such items, multiplied by the number needed, runs into an appreciable total, reclamation is a necessity.

A major construction company has solved the problem by sterilizing, immediately after use, the equipment in question and sealing it in plastic bags. For instance, every hat is cleaned, sterilized and fitted with a new sweat band. Final touch is to seal the hat inside a transparent plastic bag where it remains until removed by the next wearer. The technique has been applied to raincoasts, boots, hats, respirators, and goggles. With the first hand evidence afforded by the plastic bag, there is no question in the user's mind of the precautions that have been taken to assure his personal health. This item was contributed by J. B. Kovach, supervisor of safety, Dravo Corporation, Pittsburgh.

Heavy Bucket **Aids Hoisting of Catalysts**

For hoisting catalysts, or other solid chemicals, a bucket was designed and fabricated from a section of 24-inch pipe. The bottom is a concave head resting upon two sections of 2-inch angle iron welded to the bucket and stabilized with two cross-members. The bail is a hook-type unit carrying a loop at the top center for the hoisting line. Advantages of this hoisting equipment are: (1) it sets solidly on the ground when lowered; (2) it is heavy enough to withstand rough service; and (3) the "burred" ends of angle iron supply hand-holds for tipping the bucket after it is hoisted to the top of chemical tower.



the head that's ahead in every way . . .

This new "Serv-Rite" thermocouple head is actually small enough to be held comfortably in the palm of your hand. But size is only one of the many features that make this thermocouple head really extraordinary. It is loaded with installation and service conveniences that any user of thermocouples will appreciate at once.

The body is of malleable iron, cadmium plated for durability. A new type friction lock assures easy removal or tightening of the cap — a quarter turn does it. An asbestos gasket makes the head dirt- and moisture-proof. With a choice of ½", ¾", or 1" IPS opening for the protecting tube, you can standardize on one style head.

The connector block is of a material especially selected to withstand, without damage, temperatures up to 900° F. in continuous service. Improvements over the conventional type of inserts greatly simplify the making of the lead wire connections. The complete thermocouple element, including connector block, can be easily withdrawn for inspection.

Install a "Serv-Rite" thermocouple head and see for yourself how much better it really is.

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Information on Advertised Products

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What's New in Manufacturers' Literature

For copies of the catalogs and new equipment literature listed, use one of the convenient Reader Service Postcards on this page. Just circle the number on the card corresponding to the number of the item in which you are interested.

Conservation Solution

Vapor-mizer tanks are described in a new booklet published by Graver Tank & Manufacturing Company, Inc. The 12-page booklet presents the design features, operation and economies of the vapor-mizer, which the manufacturer terms as one of the truly important contributions" towards solving the problem of conserving valuable vapors. According to a chart which compares evaporation losses in cone roof and vapor-mizer tankage, a net savings of 3846 barrels a year may be effected by use of the latter. The booklet contains a list of standard fittings and accessories for the vapor-mizer.

Circle No. 1 on Postcard

Gear-Motor Applications

Function, design and application of gear-motors are described in a new publication made available from General Electric Company. Designated as GEA-1437H, the 16-page information guide describes the standard types of G. E. Tri-Clad gear-motors with ratings from 1/6 up to 200 hp. Cut-away photographs in the booklet show the relative position of the parts which are peculiar to the design of each motor.

Adaptability to low-speed jobs and adjustable-speed drives is explained along with a description of gear-motor maintenance. The electrical types and characteristics and special mechanical features are given. A table listing more than 200 gear-motor applications explains how to select the proper motor.

Circle No. 2 on Postcard

Hydrodesulfurization

A study containing valuable information on the Shell Oil Company hydrodesulfurization process has been published by The Lummus Company. The report contains a flow diagram and description of the process; a discussion of possible applications, investment and operating costs; utility consumption figures and economics for two 10,000-barrel-a-day units charging straight-run gas oil and cat-cracked cycle oil, respectively.

Circle No. 3 on Postcard

Liquefied Gas Transfer

Ingersoll-Rand's compressors for the transfer of liquefied gas such as LPG and anhydrous ammonia are described in a new booklet released by the company. Construction of the unit is shown by means of a sectional view, with all important operational and construction features fully captioned.

A typical installation problem is presented in the folder. Graphs indicating capacity of the various machines under different pressure conditions are shown.

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What's New in Manufacturers' Literature

Use one of the free and convenient Reader Service Postcards on this page to request copies of the catalogs in which you are interested.

Adjustable-Speed Drive

A newly improved electronic adjustable-speed drive of from ¼ to 3 horsepower is described in a new booklet released by Reliance Electric & Engineering Company. The drive was designed for powering a wide range of small industrial equipment.

Of special interest to designers of small machinery, process engineers, production executives and purchasing directors, the 12-page bulletin provides a comprehensive presentation of the Reliance V*S, Jr. Referred to as D-2102, the bulletin is written in a simple, nontechnical style.

Ten outstanding operating functions and performance features of the unit are reviewed. In addition, the booklet describes the components and optional accessories of the V*S, Jr., gives its physical dimensions and the five different horsepower ratings in which the unit is available, and graphically charts horsepower and torque characteristics.

Circle No. 5 on Postcard

Plastic Materials

Atlas Mineral Products Company has made available a 35-page booklet on plastic materials of construction. This material, which has been prepared specifically for corrosion engineers, is now being expanded and will be published in book form later this year.

Circle No. 6 on Postcard

Instrumentation Histories

More than 300 technical case histories and general information articles on industrial instrumentation, covering all of the major industries, are listed in an alphabetical index just published by the Industrial division of Minneapolis-Honeywell Regulator Company.

Covering editorial content in the firm's quarterly publication, "Instrumentation," from 1942 to 1952, the index describes instrumentation and automatic control applications in such industries as petroleum, chemical and metal finishing. Plant installation in some 162 industrial firms are described in the case histories, which range from the application of industrial instruments on huge catalytic cracking units to the utilization of automatic control equipment in the manufacture of plastic harmonicas.

Circle No. 7 on Postcard

Cork Insulation

The composition, application and uses of Witcote # 829 cork insulation are described in a new eight-page bulletin issued by Witco Chemical Company. The illustrated booklet describes Witcote # 820 as a cold-application fluid type of material composed of highly efficient insulating fillers of cork and asbestos and a bituminous base possessing unusual adhesive, waterproofing and corrosionproofing qualities. It is applied directly from the drum by hand-operated sprayguns.

Complete data as to the proper thickness and coverage are given as well as its qualifications for waterproofing and seam sealing, vibration dampening, sound deadening and insulating.

Circle No. 8 on Postcard

Revised Data on Polymers

The M. W. Kellogg Company's technical bulletin on the properties and applications of its trifluorochloroethylene polymers has been revised and expanded. It is now available as Technical Bulletin No. 1-3-53.

The new bulletin contains data on chemical resistance, permeability and optical properties of Kel-F and additional information on the "unique" electrical and mechanical properties of Kel-F plastic.

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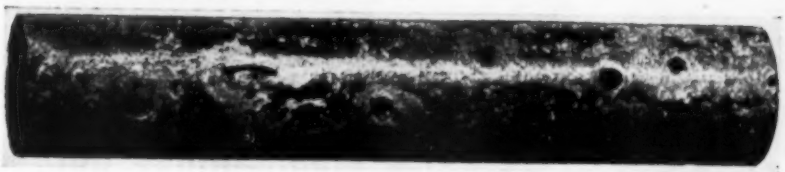
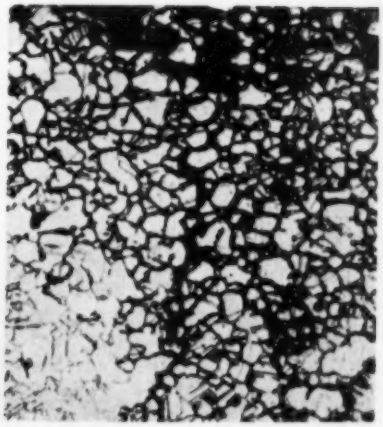
What's **NEW** in Equipment

Micrograph of same tube as below.



Non-inhibited Admiralty tube which failed from plug type dezincification accelerated by the hot wall effect.



Intergranular corrosion, non-inhibited Admiralty.

Booklet on the Serious Corrosion Problem

With practically all commercial processing engineered on a continuous basis of operation, premature failure from corrosion of tubing or piping used in the construction of various types of heat exchanger equipment can mean costly shutdowns and expensive maintenance and replacements.

The various types of corrosion which affect condenser tubes from the water side are given in detail in Bridgeport Brass Company's new "Condenser and Heat Exchanger Tube Handbook." The book deals with the properties of copper-base condenser tube alloys and their applications in the chemical, petrochemical, power, marine fields and processing industries.

A comprehensive table, which should interest design engineers, lists the physical and mechanical properties of standard condenser tube alloys. It includes the composition, mechanical properties, physical constants, thermal, electrical and fabrication properties, as well as the latest specification numbers.

Since most operations involve moisture, with various concentrations of acid, alkalis, or salt solutions, corrosion is a serious problem. It is especially troublesome in oil refining, chemical industries and electrical power plants on land and sea. In fact, it is troublesome in all processing involving liquids or moisture. Modern plants recognize this problem and maintain staffs of technical experts to devote all their time to corrosion problems. Engineers have the responsibility of keeping the ravages of corrosion at a minimum through the use of metals which are most resistant to attack and, through preventive maintenance, of keeping the equipment as clean as possible.

It is in connection with the use of metals which are most resistant to corrosion that Bridgeport Brass has published this book. Long recognizing the importance of learning more about the subject of corrosion and its effect on various metals and alloys under operating conditions, Bridgeport Brass has carried on continuous experiments in the laboratory and in the field. Also, its corrosion laboratory has carried out tests with various samples and tube alloys under actual service conditions. The valuable information collected after many years of study has been boiled down and presented in this publication. Written in semitechnical language, it is easily understandable by anyone interested in keeping his equipment in operating condition.

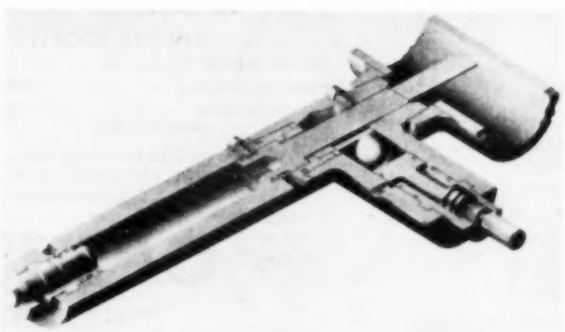
Subjects covered include: effect of water composition, pH values, dissolved gases, temperature variations, biofouling inhibitors, steam erosion-corrosion, stress corrosion and many others. The book also carries numerous tables, formulas and specifications.

Considerable space is given to Duplex tubes, which are finding wide application in corrosive conditions that are too severe for single-wall tubes. Duplex tubes, with steel to the ammonia side and copper or brass to the water or brine side, are solving a serious corrosion problem which was formerly associated with ammonia refrigeration and the manufacture of ammonia components. Free copies of the book are available to corrosion engineers and the users of condenser tubes.

Circle No. 10 on Postcard

Simple and Compact **Corrosion Detector**

Willis Oil Tool Company has designed a tool for the injection and withdrawal of metal samples in high pressure pipe lines and closed vessels. Simple and compact, the Willis Corrosion Detector subjects the component metals of the system to the fluid for scientific study of corrosion rates without shutting down the system or installing expensive bypass piping.



A removable piston carries the sample in or out of the high pressure line or vessel. Hydraulic fittings in the cylinder are used to drive or release the piston assembly.

Two models are available: the swing check valve and the ball check valve. Both are constructed to hold the high pressures found in gas plants, refineries, pipe lines, well heads, etc. By substituting the sample carrying piston with a shut off piston, the cylinder and check valve assembly may be removed. The base of the corrosion detector is screwed into a standard welded and drilled half coupling or tee.

Circle No. 11 on Postcard

MORE POWER
cleans fouled tubes faster

WILSON
MODEL TP-301
TUBE CLEANER
offers all these features

- More powerful
- Lighter weight—only 15 lb
- Shorter—only 13" overall
- Increased capacity—from ¾" up to 2½" or even 3" OD tubes
- Will operate on air pressure as low as 50 lb
- Costs less than previous models

Here is the fastest, most economical tube cleaner on the market for refinery and process heat exchangers. The Wilson Model TP-301 is the only tube cleaner which can immediately remove deposits from completely plugged heat exchanger tubes. No matter how badly tubes are fouled, the Model TP-301 puts equipment back "on stream" with a minimum of manpower and a few hours work. • Use this high speed tube cleaner to step up profits, increase output and minimize downtime. • **Write for Bulletin TW-1046**

VARIOUS CARBIDE BITS AVAILABLE
(Special Bits for Smaller Sizes)

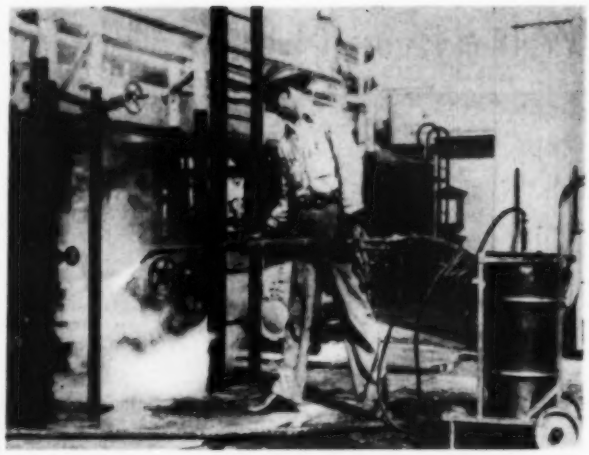
TYPE M BIT An inserted two lip Helix type for general use 21/64" to 1 17/32" OD.

SPE-DUR BIT A straight flute type negative rake angle. A good three lip "chipper" for very hard deposits. 11/32" to 1 3/16" OD.

TYPE K BIT A two lip Helix type with adaptor for general use. 1¼" to 2¾" OD.

Representatives in all principal cities
THOMAS C. WILSON, INC.
21-11 44th AVENUE, LONG ISLAND CITY 1, N. Y.
Cable address: "Tubeclean", New York

WILSON TW-825
TUBE CLEANERS · TUBE EXPANDERS



Cleaning Maintenance Cut from Days to Hours at Western Refinery

Refinery finds Oakite Detergent applied with Oakite Steam Gun makes short work of cleaning prior to repainting.

THE cleaning problem this California refinery had was simple enough. It was one of removing all dirt, grease and muck from tanks, pumps and similar equipment. But actually doing the job was not so simple. It meant tedious scraping, wirebrushing, wiping by a sizable crew. It involved struggling with hard-to-get-at surfaces. Did the Oakite Man have a better answer?

He did—as a result of his wide refinery cleaning experience. For this particular case, he suggested the Oakite 384 Steam Gun. He helped Maintenance get started that morning. By afternoon, the plant superintendent stated, "One man did about two weeks' work today".

Proving that—
in industrial cleaning it always pays to consult Oakite.

YOUR OAKITE TECHNICAL SERVICE REPRESENTATIVE.—His experience is yours to draw on. He knows "cleaning engineering" and the conditions under which refinery cleaning can be best performed. His responsibility only *begins* when you order materials. He keeps in touch with you. He sees to it that the job is done right the first time, at lowest cost. Call him in . . . no obligation.

SEND FOR BOOKLET F7629
Full of helpful information on jobs such as:
Drum reconditioning • **Descaling**
Salvage cleaning • **Tank interiors**
Paint stripping

Write to OAKITE PRODUCTS, INC.,
44C Rector St., New York 6, N.Y.

SPECIALIZED INDUSTRIAL CLEANING
OAKITE
MATERIALS · METHODS · SERVICE

Technical Service Representatives in Principal Cities of U. S. & Canada

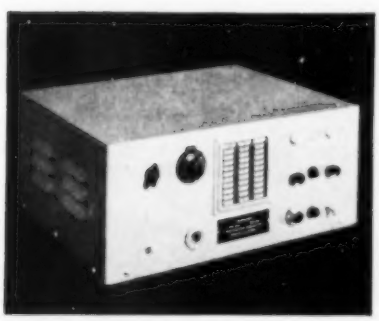
What's **NEW** in Equipment . . .

New Console Indicator

Leeds & Northrup Company's new electronic console indicator saves panel space and permits an operator to scan up to 200 thermocouple temperatures as fast as he can log them. The new unit consists of an executive-type desk with a mounting which houses the specially-adapted Speedomax Indictator and flanking switch panels. The mounting extends only 13 inches above the desk to give the operator an unobstructed view of the main control room panel.

The new console incorporates the Model D Speedomax indicator in a special housing that can be pulled out on tracks from the center of the console mounting. Because the housing slopes at 60 degrees, a seated operator can read the 25¼-inch, drum-type scale with ease as it spins from point to point and stops "dead still." Balancing time is only 4 seconds full-scale, 2.5 seconds half-scale. The scale is calibrated for single or double ranges.

Circle No. 12 on Postcard



Voltage Digitizer

Analog voltages are automatically converted into decimal digits with an accuracy of 0.1 percent (1000 counts full scale) by the Teleducer, Type 24A. Developed by Telecomputing Corporation, the instrument operates upon demand, digitizes an input voltage and holds the digital representation for a controlled period of time for purposes of display, recording, or any desired readout form. The digital output can be recorded by means of punched cards, an electric typewriter, magnetic tape or punched tape.

The Teleducer digitizes low voltage without d.c. amplification and high voltage by means of attenuators. It uses a simple-bridge balancing circuit which does not hunt or oscillate and requires only 0.8 second or less to reach balance.

Circle No. 13 on Postcard

Duplicating Machine

The Transcopy Duplex, developed by Remington Rand Inc., can make photocopies of any office record in less than a minute without developing, fixing or drying. The machine makes finished, photo-exact, positive copies of any record, regardless of type or color.

The Transcopy Duplex is a two-in-one unit, a single machine containing both a printer and a processor. Small, light and compact, it takes only a little more space than dictating equipment.

Circle No. 14 on Postcard

Multi-Use Hydraulic Shoveloader

Baker-Lull Corporation has developed a multi-use hydraulic loader designed to speed bulk materials handling for industrial plants, lumber yards and similar commercial operations.

Available with eight accessory attachments, the Baker-Lull Shoveloader is said to have up to 66 percent more lifting power than comparable units, and a cost-per-pound of 40 cents compared to 45 cents, 51 cents and 59 cents of similar equipment. Mounted on any of four national makes of industrial tractors, the Shoveloader is available in six models, rated by capacity, dumping height and forward reach.

Basic attachment for the unit is a material bucket, designed for materials loading and unloading.

Circle No. 15 on Postcard

Protective Plastic Coating

Insulcolor is a new plastic coating developed by Armstrong Cork Company for use as both protection and color identification on insulated refrigerant, cold water, steam and other lines and insulated equipment. The new finish can be either brushed or sprayed on.

A tough finish, Insulcolor will withstand temperatures to 160 F. without cracking, shrinking or crazing. It may be used over heat insulations, cork pipe covering and lagging, and also as a finish over cork-insulated air conditioning ducts.

The coating is available in white and six colors. It can be applied over standard asphaltic finishes without danger of bleed-through.

Insulcolor furnishes high resistance to bumping and abrasion. It has high water resisting properties which make it suitable for either inside or outside applications. No inflamable solvents are used, making it safe to use on the job. When dry, it is classified as fire-retardant. It is also ordorless.

According to the manufacturer, Insulcolor reduces maintenance on insulated lines to a minimum. Dust, dirt, grease, oil and soot can be readily washed off its smooth surface. On indoor and outdoor lines and equipment, it lasts "for many years without recoating." It can also be used as an adhesive for pasting down canvas, asbestos and other lagging cloths, thus eliminating the need for sewing the material.

Circle No. 16 on Postcard

HAVING TROUBLE PUMPING HEAVY OILS?
CONCERNED ABOUT LOSSES RESULTING FROM VOLUME SHRINKAGE AT LOW OIL DELIVERY TEMPERATURES? ...THEN INSTALL

Paracoil TANK SUCTION HEATERS

TO SOLVE YOUR PROBLEMS

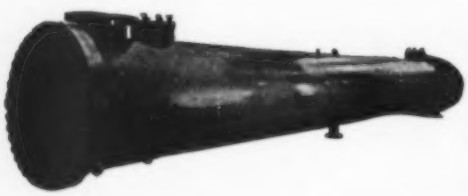
TANK SUCTION HEATER INSTALLATION

The shell is open at the inside end. The oil moves across the heating tubes as it passes through the shell to the suction connection outside the tank.

In Bulk Oil Terminals and Refineries the world over Paracoil Tank Suction Oil Heaters are licking the problem of economically preheating heavy viscous oils to permit their withdrawal from storage tanks. They are also preheating the lighter grades of fuel oils to their proper delivery temperatures to avoid the costly volume losses incurred when such oils are sold at low temperatures.

WITH PARACOIL TANK SUCTION OIL HEATERS

- **You Heat Only The Oil That Is Being Withdrawn From The Tank.** (Thus radiation losses resulting from heating entire tank contents are eliminated.)
- **Overall Steam Consumption And Heating Costs Are Held To A Minimum.**
- **Heater Tube Bundle Can Be Withdrawn For Inspection And Cleaning.** Breaking of oil suction line not necessary.
- **All Piping Connections And Gaskets Are Outside The Tank.**
- **U-Tube Design Permits Free Expansion And Contraction Of Tube Bundle.** Either high or low pressure steam can be used as the heating medium.



Prompt Shipments!
Our extensive stocks of tubing and pipe enable us to make quick deliveries to meet your immediate requirements.
Write for Descriptive Literature

SPEED UP DELIVERIES AND CUT OIL VOLUME LOSSES WITH PARACOIL TANK SUCTION HEATERS

In addition to the Paracoil Tank Suction Heaters, we also design and fabricate Line Type Discharge Heaters of any capacity. Illustrated is a Paracoil Straight Tube Type Fuel Oil Heater for bulk station service—capacity 2,000 gallons per minute, No. 6 oil, 100°F to 160°F, steam at 15 psig. Weight 12 tons.

DAVIS ENGINEERING CORPORATION
1060 East Grand Street, ELIZABETH 4, NEW JERSEY
30 Rockefeller Plaza, NEW YORK 20, N. Y.

NEW Equipment . . .

Spray-Type Foam Maker

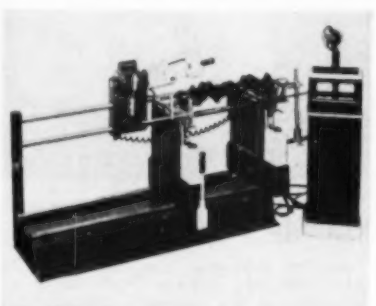
Designed to blanket flames with air foam over a wide area at one time, Pyrene Manufacturing Company's new spray-type foam maker is especially useful for overhead protection of medium-sized petroleum and chemical hazards.

The foam maker, which generates the fire-fighting foam right at the hazard, is equipped with a cone-shaped spray head which discharges an even pattern. The device is for use in fixed systems, singly or in multiples, indoors and out. Coverage of the unit ranges from 10 to 20 feet in diameter, depending on the operating pressure, which should be from 30 to 100 psi.

The foam maker can be used for protection of oil-filled transformers, pump rooms, loading racks, drip pans, drain boards and many other hazards.

This item supplements Pyrene Manufacturing Company data on pages 873-876 of The Refinery Catalog, 20th Edition.

Circle No. 17 on Postcard



New Industrial Balancer

The Model 704 Stewart-Warner Industrial Balancer is a new development of the combined efforts of Stewart-Warner Corporation and Merrill Engineering Laboratories. Quickly set up without a foreman ("less than two minutes"), the

new balancer is ideal for maintenance of high speed rotating machinery.

Elimination of vibrations allow bearings to last many times longer in the unit, and the time between tear-downs is thereby lengthened. The manufacturers claim that precision sensitivity is possible at all weights of items checked or balanced from the range of ½ pound to 1000 pounds. A turn of a knob obtains five dash positions to allow balancing at different sensitivities.

Range length is 4½ inches to 55 inches between bearing surfaces. Diametral capacity is ½ inch to 44 inches.

Circle No. 18 on Postcard

Lubricating Fluids Pump

Two years of field tests covering a wide temperature and viscosity range of clear lubricating fluids have resulted in Eco Engineering Company's bronze-impeller, positive-displacement pump for the handling of oils and greases. These lubricating fluids range from light bodied fluids such as petroleum lubricating oil, cutting oil, the standard and new synthetic hydraulic fluids to heavier diesel lubes, fuel oil, and rendered fats. Maximum capacity of the pump is 10 gpm.

The following advantages are listed by the manufacturer:

First, the pump's positive-displacement delivery, the result of two axially oscillating impellers which deliver continuous, non-surging flow without foaming or air entrainment.

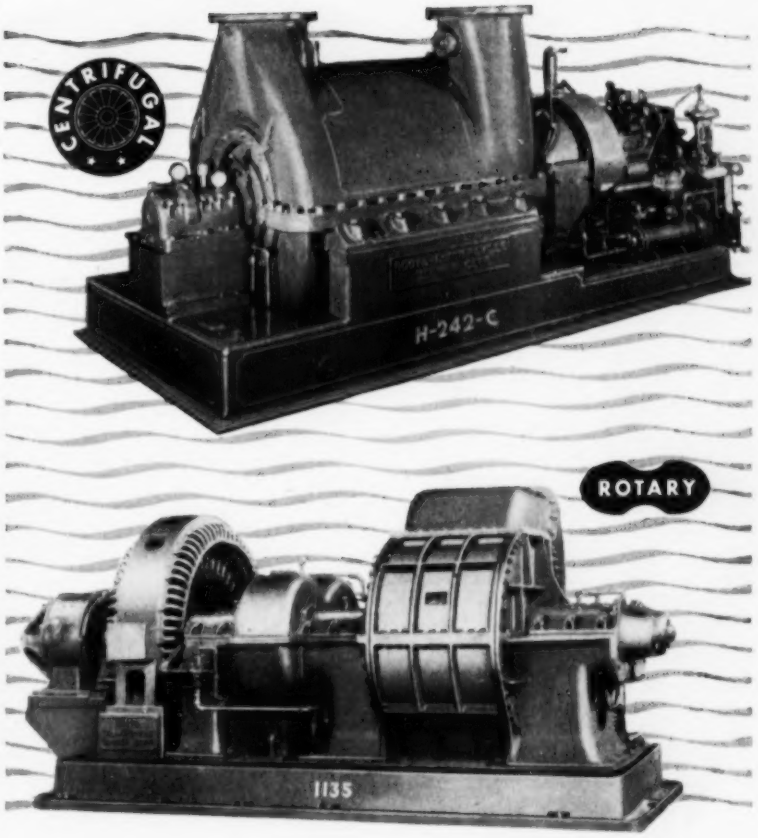
Second, its precision-machined and sintered bronze powder-metal impellers, which act like oilless bearings operating in a lubricating medium in that they absorb oils "like a sponge" and retain them, greatly minimize the dangers of heat seizures and scorched impellers.

The pump is self-priming in low temperatures. Its operation provides high efficiency with less horsepower and with smaller, lower cost motors.

Circle No. 19 on Postcard

New Chemical Activator

A new chemical activator which will reduce the manufacturing costs of GR-S cold synthetic rubber, speed up its production and make a more uniform product has been developed by Naugatuck



BLOWER RELIABILITY A "NATURAL" WITH AIR-MINDED *Specialists*

The long record of reliability established by Roots-Connersville Blowers, Exhausters and related equipment is the natural result of almost a century of experience in the exclusive business of handling gas and air for industrial purposes.

But its more than just designing and building *a* piece of machinery. Such user satisfaction comes also from the wide range of capacities and types, from which the right unit can usually be selected. Especially important, our *dual-ability line* of Centrifugals and Rotary Positives enables us to make unbiased recommendations . . . a *dual choice* available only from Roots-Connersville.

Whatever your need may be in the handling of air or gas for industrial purposes, you can look to Roots-Connersville for unquestioned reliability and long-time economical performance. Ask us for specific recommendations on any problem of handling gas or air—in any quantity.

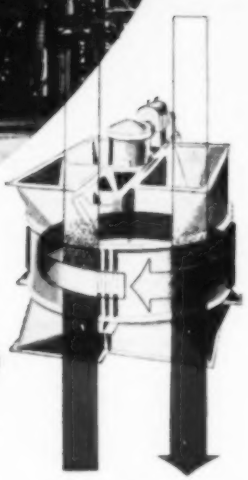
ROOTS-CONNERSVILLE
Exclusive Specialists in Handling Gas and Air

ROOTS-CONNERSVILLE BLOWER

A Division of Dresser Industries, Inc.
153 Crescent Ave. • Connersville, Ind.

with the

Ljungstrom Air Preheater



The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.

In every processing vessel that burns fuel, air preheat shows the way to save as much as *one barrel out of every five*. When refineries alone burn over 200,000,000 barrels every year, this means the *Ljungstrom Air Preheater* can recover tens of millions of *production dollars* that are now going up the stack.

The Ljungstrom removes precious BTU's from exit gases and transfers them to combustion air. Its effectiveness can be gauged from the fact that every 35-40°F of preheat means roughly a 1% saving in fuel—and Ljungstroms now in use preheat air to over 600°F.

In addition to saving as much as 20% of your fuel, more effective fuel utilization means that your equipment can deliver greater throughput . . . can burn lower grade fuels with less slagging . . . lets you eliminate convection surfaces without reducing production.

In these days of high fuel costs, every process industry should consider the Ljungstrom for new installations or modernization of existing equipment. Call or write The Air Preheater Corporation for full details.

Wherever You Burn Fuel, You Need Ljungstrom

THE AIR PREHEATER CORPORATION 60 East 42nd Street, New York 17, N. Y.

Chemical division, United States Rubber Company.

Naugatuck scientists believe the widespread use of the new activator, a sulfoxylate derivative, can result in a saving of approximately $700,000 annually for the synthetic rubber industry.

Pilot plant tests have shown that it simplifies cold rubber production and improves uniformity of operation as well as uniformity of rubber. It can be used in recipes for cold latex as well as in recipes for solid cold rubber. Laboratory tests indicate the rubber may have better aging characteristics than present types due to low iron content.

This item supplements Naugatuck Chemical Division, United States Rubber Company, data on pages 989-1004-D of The Refinery Catalog, 20th Edition.

Circle No. 20 on Postcard

Simple Valve Lubrication

Two newly designed lubricant tubes, a flat-top gun lubricant tube and a long-spouted bulk lubricant tube (pictured above), have been made available by Rockwell Manufacturing Company. The tubes are designed to give more economical and effective lubrication of the company's Nordstrom valves.

With the flat-top tube, a lube-gun can be loaded quickly by cutting off the tube top and turning a key which squeezes the contents directly into the barrel. With the long-spouted tube, a valve lube chamber can be filled easier because the spout gets the lube farther down into the valve shank than is possible with previous methods. Also, use of the spout tube simplifies inventory control, because one tube fits all Nordstrom valve sizes.

The gun lubricant tubes are available in packages of six; the bulk lubricant tubes singly and in packages of four. Eight types of lubricants are available in the new tubes.

This item supplements Rockwell Manufacturing Company data on pages 773-780 of The Refinery Catalog, 20th Edition.

Circle No. 21 on Postcard

1 Stainless steel bolts and nuts. 2 Two-piece gland and follower. 3 Bolted bonnet. 4 Tongue and groove joint. 5 Hardened wedge, chrome plated.

Why Gas Absorption Plant Chose These R-P&C Valves

● Because of the plant's isolated location the engineers felt they should standardize on a type of valve which could be used on different lines even though chemical solutions, temperatures, and pressures varied. The No. 6056 R-P&C Forged Steel Gate Valve proved to be the answer for several reasons.

First of all it has a pressure range from 380 lbs. at 1000° F., up to 2000 lbs. at 100° F. Then with its chrome stainless trim and chromium plated disc, it has high resistance to corrosion. On top of this, it's easy to service with its stainless steel gland bolts, and two-piece gland and follower.

Best of all, although the R-P&C Forged Steel Valve is premium quality it is NOT premium priced. It comes in sizes from ¼" to 2" with screwed or welding ends. If you use valves in these sizes, see your R-P&C distributor today or write our Reading, Pa., office for literature.

ACCO

R-P&C VALVE DIVISION
AMERICAN CHAIN & CABLE

Reading, Pa., Atlanta, Baltimore, Boston, Chicago, Denver, Detroit, Houston, New York, Philadelphia, Pittsburgh, San Francisco, Bridgeport, Conn.

R-P&C valves

New Equipment Literature

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TUBE EXPANSION CONTROL SYSTEM—Information. Airetool Manufacturing Co. See page 183.
Circle A3 on postcard.

STEEL FLOOR PLATE—Booklet SD-57. Alan Wood Steel Co. See page 175.
Circle A4 on postcard.

DECK PLATFORM AND MECHANICAL STIRRUPS—Catalog. Albina Engine & Machine Works. See page 246.
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REFINERY-TYPE PUMPS—Bulletin 52B7775. Allis-Chalmers Manufacturing Co. See pages 16-17.
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LIQUID GRAVITOMETER—Bulletin 111-R2. American Recording Chart Co. See page 244.
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CATALYTIC REFORMING PROCESS—Details. Atlantic Refining Co. See pages 52-53.
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CENTRIFUGAL PUMPS—Catalog "M." Aurora Pump Co. See page 258.
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PRESSURE VESSELS—Bulletin S-14. The Babcock & Wilcox Co. See pages 12-13.
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SWING JOINTS—Catalog No. 400. Barco Manufacturing Co. See page 216.
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FORK TRUCKS—Literature. Clark Equipment Co. See page 83.
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CORROSION-FREE PACKING SERVICE IN PUMPS AND VALVES—Booklet. Crane Packing Co. See page 249.
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TANK SUCTION HEATERS—Literature. Davis Engineering Corp. See page 236.
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VALVES—Bulletin 332-G. Okadee Company. See page 176.
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REFINERY PAINTING GUIDE—Brochure A-770. The Sherwin-Williams Co. See page 172.
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PUMPING UNITS—Information. Southern Engine & Pump Co. See page 256.
Circle R4 on postcard.

STRAINERS—Catalog 68-S. Strong, Carlisle & Hammond Co. See page 241.
Circle R5 on postcard.

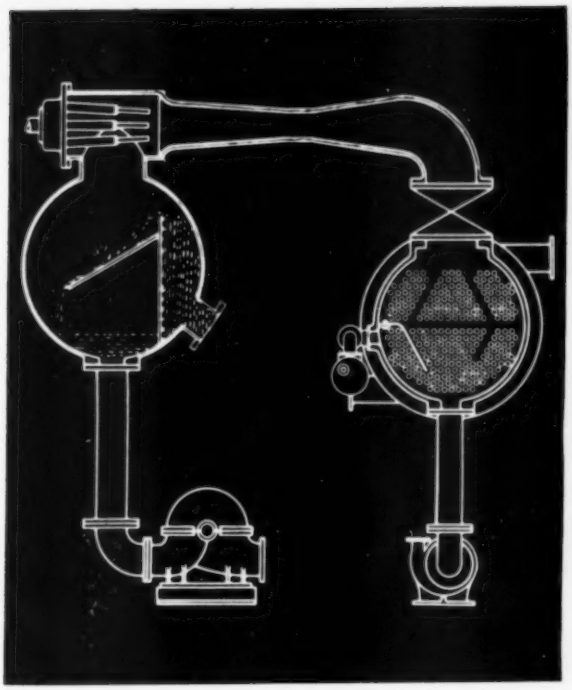
STEAM TURBINES—Bulletin S-116. The Terry Steam Turbine Co. See page 39.
Circle R9 on postcard.

RADIOACTIVITY AND THE PETROLEUM INDUSTRY—Survey. Tracerlab Inc. See page 252.
Circle S2 on postcard.

ELECTRICAL WIRES AND CABLES—Brochure. United States Rubber Co. See page 32.
Circle S3 on postcard.

ALLOY STUDS AND BOLTS—Catalog. Victor Products Corp. See page 260.
Circle S4 on postcard.

■ LIST CONTINUED ON PAGE 242



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A Chill-Vactor is a three-stage steam-jet vacuum unit which serves to flash-cool water and certain other liquids through temperatures down to 32° F. No chemical refrigerant is used. There are no moving parts. Water literally "cools itself" by partial evaporation at high vacuum. Vacuum refrigeration is usually less expensive than mechanical refrigeration in first cost as well as operating cost.

Chill-Vactors are producing chilled water in industrial plants throughout the world. They are cooling chemical solutions, fruit juices, milk, whiskey mash, etc. Bread and other baked goods have been vacuum cooled successfully for years. Other products, such as lettuce, spinach, celery and other leafy vegetables, are being cooled to temperatures around 33° F. in quantities up to 200 cars a day.

The Chill-Vactor is only one type of steam-jet evactor manufactured by Croll-Reynolds. Let our technical staff help you with any or all of *your* vacuum problems.

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Available for pressures to 600 psi, screwed and flanged. Sizes ¼" to 4".
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80 Series Trap

"T" Type Strainer

STRONG

Although WESTON provides sensing elements of various forms for special applications, the element in all standard WESTON Industrial Thermometers is a *multiple helix* as illustrated above. Why the more costly *multiple*, instead of the single, helix? *Just one reason.* WESTON's twenty years experience producing bi-metal thermometers for industry has furnished convincing proof that the shorter, non-sagging *multiple* helix provides better accuracy, over longer periods. And while it provides other advantages, the one thing most thermometer buyers demand is long-term dependability. You get it, in extra measure, in WESTON Thermometers with *multiple* helix. WESTON Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

WESTON *Thermometers*

New Equipment Literature . . .

PROCESS VALVES—Bulletin 698. W-K-M Company. See page 76.
Circle S6 on postcard.

CHLORINATION EQUIPMENT—Information. Wallace & Tiernan Products, Inc. See page 251.
Circle S7 on postcard.

HEAT EXCHANGERS—Bulletin No. 250. The Whitlock Manufacturing Co. See page 170.
Circle T1 on postcard.

ACID PUMPS—Details. A. R. Wilfley & Sons, Inc. See page 62.
Circle T2 on postcard.

CHECK VALVES—Bulletin WH-851. Williams Gauge Co. See page 212.
Circle T3 on postcard.

TUBE CLEANERS AND EXPANDERS—Bulletin TW-1046. Thomas C. Wilson, Inc. See page 234.
Circle T4 on postcard.

CORROSION CHART—Wolverine Tube Division, Calumet & Hecla, Inc. See page 55.
Circle T5 on postcard.

CENTRIFUGAL PUMPS—Bulletin W341-B15. Worthington Corp. See page 8.
Circle T6 on postcard.

STEAM TURBINES—Bulletin 1966. Worthington Corp. See page 10.
Circle T8 on postcard.

STEAM TRAP SELECTOR—Yarnall-Waring Co. See page 44.
Circle T10 on postcard.

Mechanical Engineers Plan Houston Meeting in September

The American Society of Mechanical Engineers, Petroleum division, will hold its annual Petroleum Mechanical Engineers Conference at the Rice Hotel in Houston on September 28 through 30. Details of the program have not been announced but a large attendance is expected.

Union Oil Veteran Retires

For the past 27 years Homer Ambrosier has been superintendent of the Maltha refinery near Bakersfield, Calif., for Union Oil Company of California. On June 1 he retired after 42 years of service with the company.

G. S. Baumgartner, engineer of the lube treating department at Union's refinery at Oleum, Calif., succeeds Ambrosier. B. L. Johnston has been appointed assistant superintendent at Maltha.

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

Aminoethyl mercaptan
Acetyl fluoride
Hydrazine nitrate
Cycloheptane
Diethyl mercury
Di-tert.-Butyl magnesium
Diborane
3,3-Dimethylpentanone-2
1,7-Dimethylxanthine
3,6-Dinitrocarbazole
2,4'-Diphenic acid
2-Methyl-5-vinylpyridine
1,2,4-Triaminobenzene
para-Vinylbenzoic acid
3-Nitro-2,5-dichlorothiophene
8-Octadecene
4-Hydroxyphthalic acid
Acenaphthalene
2,2'-Diquinoline

Who's Meeting

AICHE

The fifth annual Institute lecture of the American Institute of Chemical Engineers will be given at the organization's annual meeting at the Hotel Jefferson, St. Louis, Mo., Dec. 13-16, 1953, by George Granger Brown, dean of the College of Engineering and Edward De Mille Campbell, University professor of engineering at the University of Michigan, Ann Arbor. Dr. Brown's topic will be on thermodynamics, one of the fundamental basic studies underlying chemical engineering.

The Institute lectures are a continuing feature of the AIChE annual meetings since each provides a comprehensive survey of some important aspect of chemical engineering by a prominent engineer.

ASME

The semi-annual meeting of The American Society of Mechanical Engineers was held in Los Angeles, June 28-July 2, in conjunction with the Heat Transfer and Fluid Mechanics Institute. Of particular interest to refiners was the paper on "Comparison of Electric Motors and Steam Turbines as Drivers for Fluid Catalytic Cracking units" by H. C. Mayo of The M. W. Kellogg Company.

Driver Economics Pinpointed: Plant investment costs can be substantially reduced in fluid catalytic cracking units by the use of electric motor drivers in cases where the steam system is inadequate and where reliable power is available without too great a capital expenditure. The operating cost for low pressure condensing steam turbine installations is higher in most areas than for electric motors supplied by purchased power. The operating cost for high pressure, high temperature steam turbine installations is lower in many areas than for electric motors. However, in areas where cheap hydroelectric power is available, the operating cost of motor drivers may be lower.

The maintenance costs of electric motors and the electrical system are lower than for turbines, condensers and cooling towers. Cooling water requirements are reduced from 30 to 50 percent and space for cooling towers and steam generators is greatly reduced by the use of motor driven compressors. Also well designed electrical systems will provide the required service continuity. Further, commercially available constant speed centrifugal compressors have sufficient operating range for any application in a fluid catalytic cracking unit.

Gas Compressor Design: Tracing the development of gas compressor plants, L. F. Scheel, The Fluor Corporation, pointed to the $44 increase in unit cost over the $100 per horsepower figure of twenty years ago. However, the difference in operating expense of the older design plants compared with the advanced design plants is an annual premium of 62 percent on the added investment. Among the advancements are cast iron valves and fittings replaced with steel and weld fitting, larger and more efficient scrubbers, automatic and remote controls. It cannot be concluded that plant refinements earn the entire premium nor can it be said that they do not contribute to this economy.

Steam Piping Recommendations: W. G. Benz and R. H. Caughey, M. W. Kellogg Company, presented the results of a metallurgical investigation of fabricating austenitic stainless steel steam piping for operation at 1100 F. The first conclusion was that ferrite

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Meetings of Minds . . .

bearing type 347 weld deposits should continue to be the practice in welding these piping systems for use in electrical generating stations. Continued studies toward the development of a satisfactory fully austenitic deposit are recommended.

Second, electrode composition should be balanced to produce deposits containing from 1-4 percent ferrite. Third, levels of certain elements in the deposit should be held within the following limitations: carbon—0.07 to 0.10 percent, silicon—5 x percent carbon, columbium—0.60 to 0.90 percent.

Finally, a postwelding solution heat treatment at 1950 F. is recommended for type 347 piping operating at elevated temperatures. The steps in the shop fabrication of piping assemblies were also described in detail by the authors.

WPRA

In its Chicago regional meeting, the industrial relations session of Western Petroleum Refiners Association was opened with "Executive Development or Management by Proxy" by John R. McNulty, manager, industrial relations, Husky Oil Company.

He pointed out that of 422 men he contacted who left their companies, none did so because of money, security, or location. The reasons given: (a) desired more responsibilities, (b) disagreed with management's policies and (c) desired a change of activities. A large percentage of the companies still use the sons and relatives of the families as presidents and executive positions of the companies. About 30 percent of the large companies bring in the top executives from the outside. What is needed is executive training within the company such as the programs of Creole Petroleum Company and Johnson & Johnson Company. Husky Oil Company uses the Johnson & Johnson "case" method. Here the

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IN THE FUTURE

JULY 22–25	Silver Bay Conference on Human Relations in Industry, Silver Bay, New York.
SEPT. 6–11	American Chemical Society (124th National Meeting), Conrad Hilton Hotel, Chicago.
13–16	American Institute of Chemical Engineers, Fairmont and Mark Hopkins Hotels, San Francisco.
15–16	American Petroleum Institute (Executive Committee), Greenbrier Hotel, White Sulphur Springs, W. Va.
16–18	National Petroleum Association (51st Annual Meeting), The Traymore, Atlantic City.
21–25	Instrument Society of America (8th National Instrument Conference and Exhibit), Sherman and Morrison Hotels, Chicago.
24–25	Western Petroleum Refiners Association (Regional Meeting), Henning Hotel, Casper, Wyo.
27–30	American Society of Mechanical Engineers, Petroleum Division (Annual Petroleum Mechanical Engineers Conference), Rice Hotel, Houston.
27 to Oct. 2	American Society for Testing Materials (Committee D-2), Shoreham Hotel, Washington, D.C.
OCT. 8– 9	California Natural Gasoline Association (28th Annual Fall Meeting), Ambassador Hotel, Los Angeles.
11–17	Oil Progress Week.
19–23	National Safety Council (Annual Congress), Conrad Hilton, Congress, Morrison, Sheraton, Chicago.
22–23	Western Petroleum Refiners Association (Regional Meeting), Garrett Hotel, El Dorado, Ark.
24	Natural Gasoline Association of America (Regional Meeting), Blackstone Hotel, Tyler, Texas.
NOV. 2– 4	American Oil Chemists' Society (27th Fall Meeting), Sherman Hotel, Chicago.
2– 6	American Institute of Electrical Engineers (Fall General Meeting), Muehlebach Hotel, Kansas City, Mo.
9–12	American Petroleum Institute (33rd Annual Meeting), Conrad Hilton Hotel and Palmer House, Chicago.
19–20	Third Annual Instrument Short Course, Los Angeles Harbor Junior College, Wilmington, Calif.
21	Natural Gasoline Association of America (Regional Meeting), Herring Hotel, Amarillo, Texas.
29 to Dec. 4	American Society of Chemical Engineers, Statler Hotel, New York.
DEC. 13–16	American Institute of Chemical Engineers (Annual Meeting), Jefferson Hotel, St. Louis.

Meetings of Minds . . .

men who are expected to become the executives of the company participate in actual case problems. The problem may be one that the board of directors discussed only the day before. Recommendations and decisions are made and compared with those of the actual executives.

Other papers in the Industrial Relations session included "A Practical Safety Program," "The Supervisor as a Key to Good or Bad Human Relations" and "What is the Basis for an Effective Employe Suggestion Program?"

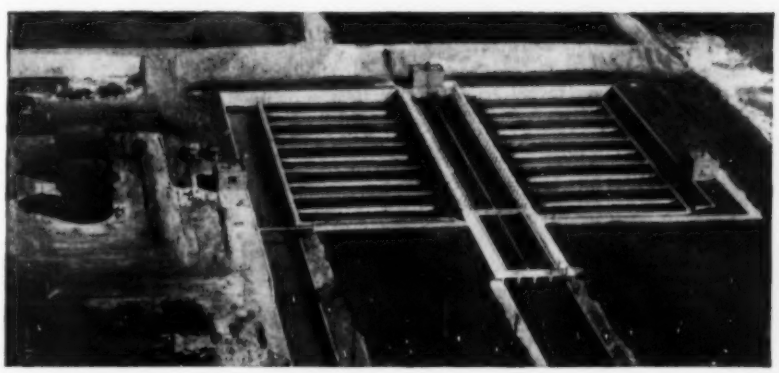
New Instruments. In the technical section of the meeting Dr. Jacobs, technical director, Engineering Research Department, presented a paper co-authored by T. A. Abbott, Manager, Engineering Research Department of Standard Oil Company (Indiana) entitled "Some Developments of Monitoring and Inspection Instruments for Refineries." Covered were instruments which measure and control the physical properties of a stream instead of merely the pressure and temperature and include:

(1) Reid vapor pressure controller for continuous gasoline blending.
(2) conductivity of acid streams
(3) flash point continuous analyzer and recorder
(4) corrosivity of crude oil by measurement of electrical resistivity
(5) locator of pipe line scrapers
(6) a laboratory device which measures the % H_2 in hydrocarbons directly. (This makes use of beta ray as a source of energy and makes a determination in five minutes as compared to ½ to 4 hours with the usual combustion type of apparatus.)

Furnace Tube Spacing. Robert D. Reed, chief engineer of the John Zink Company discussed the importance of the tube-to-wall spacing in a radiant furnace. He presented experimental data to clinch his argument that there is increased heat transfer at spacings up to one pipe diameter. There is no further increase at distances of 2, 3 and 4 diameters, and actually a slight decrease at 5 diameters.

E. W. Ellis and H. E. Carlson of Cities Service Oil Company, East Chicago, Ind. discussed lime-soda-phosphate treatment of boiler feedwater. Dr. W. F. Krause, technical manager of Globe Oil and Refining Company, advanced the idea of the refiner working on his air and water polution problems in such a way that he will be a better member of his community.

Hardinge
RECTANGULAR CLARIFIERS
for refinery waste water



Aerial view of eleven Hardinge Rectangular Clarifiers processing waste water from two Ohio refineries. The central unit acts as the primary or influent chamber from which the water is distributed in opposite directions to each of the five side clarifiers. The effluent is on the left. 95% of the oil is recovered.

The Hardinge Rectangular Clarifier has been found to be the answer to the refinery waste water disposal problem by a number of oil refiners in different parts of the country. One or more of these units installed in the effluent waste water channel of an oil refinery will remove surface oil almost completely and most of the settleable solids or sludge, making the water sufficiently clean to permit disposal directly into nearby streams. Also, the lagoon required for the sludge is only a fraction of the size of that required for the unclarified waste water. Further, the oil skimmed from the surface can be reclaimed and sold. 30 Hardinge units are now in operation at oil refineries in this country.

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NEW **BOOKS**

Petroleum Resources Study

Petroleum in the Western Hemisphere, Independent Petroleum Association of America, P. O. Box 1019, Tulsa 1.

This 180-page book represents the most extensive study of Western Hemisphere petroleum resources ever conducted. The study was made over a two-year period by an industry committee composed of 44 experts in petroleum economics, production, geology, law and engineering. It provides a comprehensive analysis of future availability of petroleum in the Western Hemisphere countries through 1960.

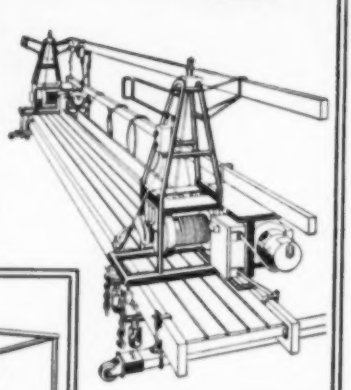
The book also established a formula for predicting future conditions in the petroleum industry as related to production, demand, imports, income, drilling, reserves and productive capacity.

It contains exhaustive reports on past, present and future trends in petroleum production, productive capacity and reserves, hemisphere supply and demand, industry materials requirements, and governmental policies and laws in oil producing countries as they affect petroleum operations.

It is noted in the forward of the book that "the findings of this study demonstrate that neither the United States nor the Western Hemisphere need ever be short of petroleum products in the forseeable future."

ALUMINUM DIAMOND PLATE DECK PLATFORM

Platform as shown may be used as a 6, 16, 22 or 28-ft. swing stage. Platform consists of two 6-ft. and one 16-ft. sections. Can be used as a swing stage, single stirrup or basket. Air or electric operated.



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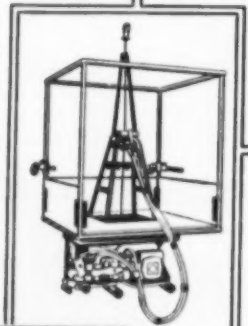

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2100 N. Albina Ave. Portland, Oregon

Chemical Machinery

Chemical Process Machinery, E. Raymond Riegel, Reinhold Publishing Corporation, 330 W. 42nd Street, New York 36. $12.50.

Like its predecessor, this second edition was designed to be an exhibit of the devices which are obtainable in the open market, some from stock and others more generally by casting, assembling or manufacturing from standard designs placed at the disposal of the customer. All the material has been reexamined; new descriptions and items included; obsolete matter has been dropped.

This enlarged edition brings the material of the previous volume abreast of the latest developments in the equipment of the chemical and process industries. Numerous new diagrams, photographs and tables make the construction and operation of recently employed machinery readily understandable to students and laymen as well as engineers.

Among the new devices described in Riegel's book are multispheres and multicylinders, and high-speed centrifugal separators. New descriptive material is included on distillation, the mixing of liquids and instruments for the control of chemical processes. Also included are greatly expanded descriptions of evaporators, driers, heating and cooling equipment, pumps and many other important topics.

Classification of equipment by function gives the discussion a natural and logical organization which will appeal both to students and to practicing industrial engineers.

Coatings Preparation

Report on Surface Preparation of Steels for Organic and other Protective Coatings, National Association of Corrosion Engineers, 1601 M & M Building, Houston 2. $1. (Five or more copies to one address, $.50 each.)

This second interim report dealing with methods of preparing steel surfaces for coatings has been published by the Technical Practices Subcommittee 6-G of the National Association of Corrosion Engineers.

The report covers recommendations and explains methods whereby the surfaces of steel may be prepared for painting with organic and other coatings by means of weathering, wire brushing, grinding, flame conditioning, nozzle blast cleaning (both wet and dry), wheel blasting, chemical pickling, electrolytic pickling and numerous other related methods. Accepted standards are discussed and safety measures indicated.

Plant Maintenance

Techniques of Plant Maintenance—1953, Clapp & Poliak, Inc., 341 Madison Avenue, New York 17. $6.

Reflecting the growing interest in maintenance for cost reduction, this 288-page volume contains the text of 61 sessions on various aspects of maintenance and plant engineering held in Cleveland in January. Highlight of the publication is the discussions of the more than 2200 production and maintenance men who attended the conference. Their discussions represent what is

probably the best engineering thought on maintenance problems available in the country today. Texts of 20 papers which were read are also included.

Electrical Insulation

ASTM Standards of Electrical Insulating Materials, American Society for Testing Materials, 1916 Race Street, Philadelphia 3. $5.25.

Seventy-five widely used ASTM Standards in their latest approved form are contained in this 1953 edition. Included are 56 test methods, 16 specifications, 2 recommended practices—one for the purchase of uninhibited mineral oil for use in transformers and in oil circuit breakers, the other for maintaining constant relative humidity by means of aqueous solutions—and 1 list of definitions with procedures relating to conditioning and weathering.

The Standards cover: insulating shellac and varnish; plates, sheets, tubes, rods, and molded materials; mineral oils for electrical insulation; ceramic products (glass, porcelain, steatite); solid filling and treating compounds; insulating fabrics; insulating papers; mica products; electrical tests; servicing units and conditioning methods; plastics for electrical insulation; rubber tape and electrical protective equipment; textile materials for electrical insulation; and general test methods.

Appendices cover significance of tests of electrical insulating materials, and proposed recommendations for writing statements as to the usefulness of tests of electrical insulating materials.

An important innovation is the use of Bible paper for a thinner volume.

Automatic Control

Principles of Automatic Control, Instrument Society of America, 1319 Allegheny Avenue, Pittsburgh 33. $1.25.

This 32-page booklet is the text of the sound film, "Principles of Automatic Control," which describes: 1) Justification of Automatic Control; 2) Design of an Automatic Controller; and 3) Application of a Controller to a Process. The film was produced by the society and has been shown to company instrument trainees and college students in the U. S. and Canada.

Sulfur Sources Survey

New sources of raw sulfur to supplement current industrial stockpiles is encouragingly reported in a new survey booklet released by Midwest Research Institute of Kansas City, Mo. Increased use of sulfur from natural and refinery gas, and greater utilization of pyrites to produce sulfur, are included in the forecast by the chemistry staff at Midwest Research Institute.

The report is the first in a series of Institute studies of various technological trends in Mid-Western industry. Other reports, now in preparation, will deal with the applications of industrial instrumentation, and opportunities for chemical expansion in the Mid-West.

Pyrites will likely develop into a major source for sulfuric acid in the years ahead, according to the sulfur survey. Smelter gases and substitutes such as gypsum and calcium sulfate also will become increasingly important.

What Suppliers Are Doing

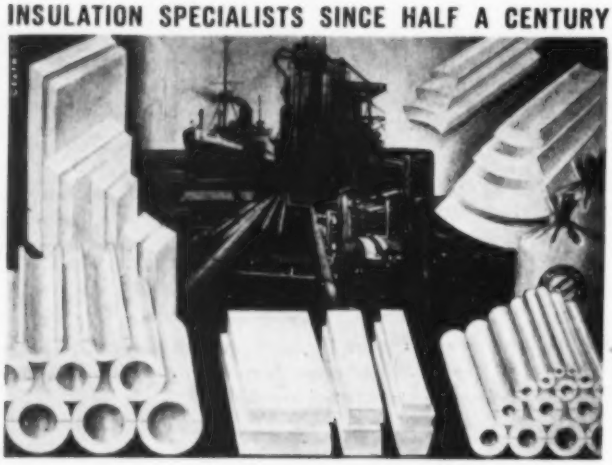
Witco Completes Additions at Chicago—

The new 25,000-square-foot warehouse recently completed at Witco Chemical Company's Chicago plant replaces the 20,000-square-foot warehouse that was destroyed by fire in June, 1952. Built at a cost of 150,000 the new warehouse is completely equipped with a sprinkler system to guard against a recurrence of last year's fire.

Elsewhere at the Chicago plant, a steam stripping column, now being added to the ester production facilities, is expected to double the plant's ester production. It is expected to be completed this month.

Attached to the new warehouse is a two-story building, in which are contained offices of the Chicago plant which have been consolidated into the one building.

INSULATION SPECIALISTS SINCE HALF A CENTURY



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Oakite Announces Five Changes In Management Organization

Five changes in the management organization of Oakite Products, Inc., have been announced.

H. Liggett Gray, formerly vice president, was elected second vice president; Frank L. Oldroyd, general sales manager of the Industrial division, was given the additional duties of vice president; Eustace Lingle and Van Dorn C. Smith were elected vice presidents; and George M. Seib, assistant manager, was elected secretary of the company.

In his new post, Gray will be responsible for matters pertaining to overall management functions. Lingle, in addition to his duties as vice president, will continue to cooperate with the general sales manager on the sales organization and will be responsible for the functioning of its engineering, technical service and sales development departments. In his new capacity, Smith will be concerned with consultation work of a general technical and sales nature. Seib, the new secretary, will continue to supervise personnel department operations and be responsible for general office administration policies.

Clark Bros. Opens New Office In Kansas City Under Van Campen

Opening of new Kansas City, Mo., district offices has been announced by Clark Bros. Company. It will be under

Van Campen

Barnes

the direction of A. G. Van Campen, formerly district manager of the Clark Tulsa, Okla., office. To fill the position vacated by Van Campen is William H. Barnes. Both men have had wide field experience.

Company Changes

Robert J. Entenman has joined **Hooker Electrochemical Company** as a chemical engineer in the process study group, and **William B. Cocoran, Jr.**, has become a draftsman in the engineering department. Entenman was formerly in the Ordnance Corps, U. S. Army, Cocoran with Mathieson Chemical Company . . . **General Controls Company** has recently expanded its Glendale, Calif., plant which is now in use for production of temperature controls for home and industrial use, aircraft controls and valves and a variety of other devices in the controls field . . . **George Quinlan** has been appointed manager, procedures and statistics division, General Sales department, Worthington Corporation. He fills a vacancy created by the recent retirement of **J. H. Maxwell.** Quinlan has been with Worthington since 1936 . . . **Richard H. Lamberton**

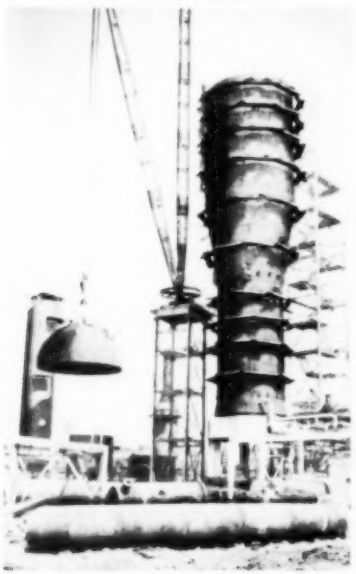
REFINERY PROCESS NEWS

PUBLISHED BY REFINERY PROCESS DIVISION, THE M. W. KELLOGG COMPANY — JULY 1953

First Inverted Orthoflow Unit Completed Soon

Shown here as it passed the 75%-completion point is the first of the new type Orthoflow Fluid catalytic crackers. It is currently about to be placed on stream at a major Mid-western refinery.

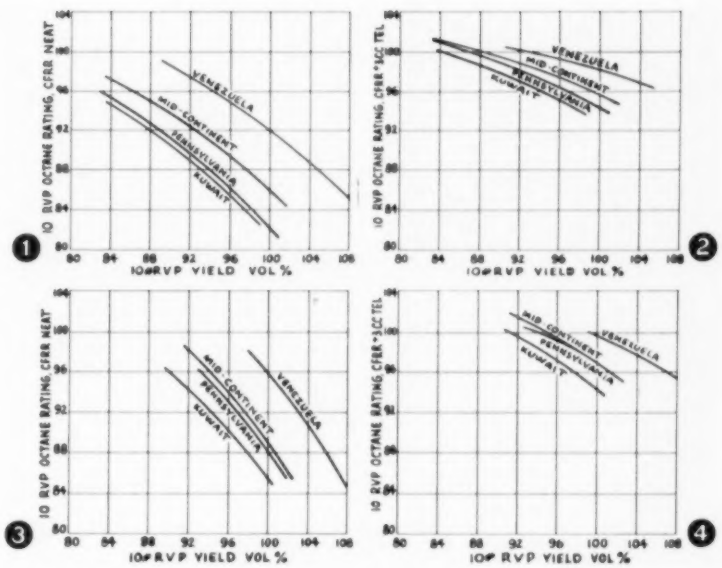
Known as the Model "B" Orthoflow, it is a variation of the original Orthoflow design. Principal reason for the new design, with the regenerator above the reactor, is the expected reduction in the operating costs in comparison with the conventional Model "A" unit, several of which are now operating in the United States and Canada.



The regenerator of the Model "B" design operates at a lower pressure than the reactor in order to maintain the required flow within the system. Thus compressed air is being charged to the vessel which is at the lower pressure as opposed to the situation in the conventional Orthoflow where the regenerator is operated at the higher pressure.

Eleven Orthoflows, including both types are now either in operation or under construction. With fresh-feed capacities ranging from 2,500 to 28,000 BPD, they are located virtually all over the world. They all represent marked simplification in the Fluid catalytic crack-

(Continued on following page)



Sinclair-Baker Catalyst Promises Substantially Lower Operating Costs and Increased Yields

Employing the recently announced Sinclair-Baker platinum catalyst – a joint development of Sinclair Research Laboratories, Inc. and Baker & Company – Kellogg's new catalytic reforming process is expected to produce excellent yields of high octane product from a wide variety of feed stocks.

The new catalyst is a regenerative type and has two major advantages over existing commercial platinum catalysts: (a) the catalyst maintains high activity over considerably longer periods of time, resulting in substantially lower catalyst operating costs, and (b) it has a greater ability to convert low octane paraffinic components to high octane aromatics.

In addition to this ability to aromatize paraffins, the undesirable hydrocracking of feed to butane and lighter gases is minimized, more hydrogen being produced. Further, the regenerative properties of the catalyst provide means of reactivating it in place in case of process upsets. Regenerative processing gives maximum catalyst life, in terms of barrels of production per pound of catalyst, while maintaining optimum yield-octane ratios.

Catalytic reforming at moderate pressure with this catalyst is summarized by the yield-octane curves shown above for typical naphthas. Figure (1) presents the data for 10# RVP clear research octane and Figure (2) the data on a leaded basis – both for continuous processing. Figures (3) and (4) give the data for the regenerative process for 10# RVP clear and 3cc leaded bases.

In all cases, outside butane may be used to produce 10# RVP reformate. Low C_3-and-lighter gas yields reflect the selectivity of the catalyst. The high net hydrogen production offers an important refinery source of H_2 for desulfurization and petrochemical processing.

Since it is now fairly certain that the octane demands for future automotive transportation will require naphtha reforming, the choice of one of several reforming processes becomes important. The selection should take into account royalties, yield/octane ratios and catalyst productivity. Preliminary data indicate that reformate production will range from 20 to over 200 bbls. per pound of catalyst, depending upon the feed stock and the product quality required. Direct operating costs for labor, utilities and maintenance should not exceed $0.20 per barrel of reformate.

CONTINUED FROM PRECEDING PAGE

Inverted Orthoflow....cont.

ing process from a mechanical engineering standpoint... and have continued to display the overall ease of operation typical of the Fluid process.

Tests during a period of more than three months also prove that the catalyst loss factor of the Orthoflow is now as low as that of the best side-by-side Fluid units. A simple modification in the regenerator of the first domestic Orthoflow has radically reduced the amount of catalyst lost with the flue gases.

This particular unit was originally designed for an 8,300 BPD throughput. Operating on synthetic MS catalyst it is now running regularly at 9,300 BPD, with conversion at 67%. Despite a certain amount of naphtha in the feed, debutanized gasoline averages 93 octane clear.

The other units in operation substantiate the fact that the Orthoflow is simple to operate, produces good yields of high quality products, and the minor modifications made to effect catalyst saving do not alter its basic design advantages or increase its investment cost.

New Australian 70,000-BPD Refinery Well Underway; Will Include Orthoflow

Big things are happening in Australia. Search for oil goes on in the Exmouth Gulf area, and seventeen miles from Fremantle, Australia's largest refinery is being built at Kwinana (see photo) under Kellogg supervision for AIOC. When it comes on stream in 1955, it will process 70,000 BPSD supplying 49% of the country's current needs.

Included in the plant will be two 35,000 BPD atmospheric distillation units—complete with stabilizers, solutizers, and caustic washers—plus a 24,000 BPD vacuum unit. The catalytic cracking plant will be of the new Kellogg Orthoflow Fluid design, similar to units in the U.S. and Canada which are matching the performance records of conventional side-by-side crackers.

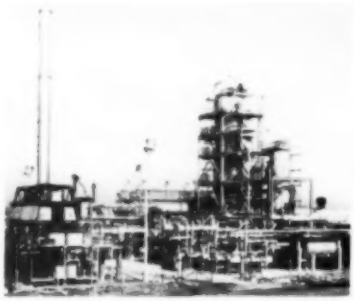
Plant Includes Hydrofiner

Hydrofining will be used for desulfurizing kerosene and gas oil. Hydrogen for this operation will be obtained from the catalytic reforming unit also being installed.

For further information, technical data, etc., on any refining process, write

England's First Deasphalter on Stream

The Kellogg International Corporation, which erected the unit to a Kellogg design, has placed this propane deasphalter on stream at Kent, England. Part of an entirely new refinery, the plant has a capacity of 4,500 barrels per day. It is the first unit of its type to be installed in the British Isles.



Like a Candle Into a Candlestick

...goes this 65-ton fractionating column into a Fluid catalytic cracker in England. Designed by Kellogg it is 106 feet long and 14 feet in diameter. When in service it will handle approximately 10,000 BPD of cracker effluent daily.

When finished, this will be the third Fluid catalytic cracker Kellogg has completed in the British Isles within the past few months.

REFINERY PROCESS DIVISION

THE M. W. KELLOGG COMPANY

225 Broadway, New York 7, N. Y.

Also Jersey City,
Los Angeles, Tulsa, Houston, Toronto,
London and Paris

KELLOGG — subsidiary of PULLMAN

has been appointed Mid-West manager, Plate and Welding division, **General American Transportation Corporation.** He will work from an office in Chicago . . . **K. C. Dileman,** assistant to **L. M. Wallace,** general traffic manager at **A. P. Green Fire Brick Company,** has been appointed traffic manager. Wallace recently retired . . . **Rust-Oleum Corporation** has added two industrial distributors to its district sales organization: **Griswold-Sohl Automotive Company,** Columbus, Ohio; and **Mill Supplies, Inc.,** Greenville, Miss. . . . **Eric G. Peterson** has been appointed executive vice president of **Peabody Engineering Corporation . . . Witco Chemical Company** has appointed **Charles W. Grubb** sales manager of the New England states with headquarters in Boston. A salesman in the Boston office for three years, Grubb succeeds **Goodwin Bangsburg . . . Copper Alloy Foundry Company** has acquired an interest in **Vanton Pump Corporation** and will add to its production of stainless steel products a line of plastic pumps, valves, accessories and fittings . . . **Pyle National Company,** Chicago, has acquired all tools, dies, molds, machinery and equipment of **M. B. Austin Company,** Northbrook, Ill., necessary to make a complete line of electric service entrance fittings.

BS&B Division Gets Tom Casey As Tulsa District Sales Manager

Tom Casey has been appointed Tulsa district sales manager for the Controls and Safety Head division, Black, Sivalls & Bryson, Inc. In the new capacity, he will have supervision of sales and service activities for the division in the Tulsa sales district.

Casey

For the past seven years he has been with BS&B as a salesman in the Tulsa office. He will headquarter at the company's Tulsa plant. The BS&B Control Line includes automatic controls for oil, gas and chemical processes.

Canadian Consulting Company Purchased by Fluor of Canada

Fluor Corporation of Canada, Ltd., has purchased an interest in H. G. Acres & Company, consulting engineers, of Niagara Falls, Ontario. Fluor of Canada is a subsidiary of Fluor Corporation, Ltd., of Los Angeles.

No change in policy, management personnel, or company name of the Acres Company is contemplated. S. W. Andrews, president of Acres, and A. W. F. McQueen, vice president, have been elected directors of Fluor of Canada.

New Tracerlab Building Will House Firm's Western Division

Construction at Richmond, Calif., of a new $100,000 building to house its Western division has been announced by Tracerlab, Inc. The new 15,400-square-foot building will replace outgrown quarters the company has occupied in Berkeley, Calif., since 1948.

Front section of the new structure will be two stories, providing office

acids . . . gases . . . hot liquids . . .

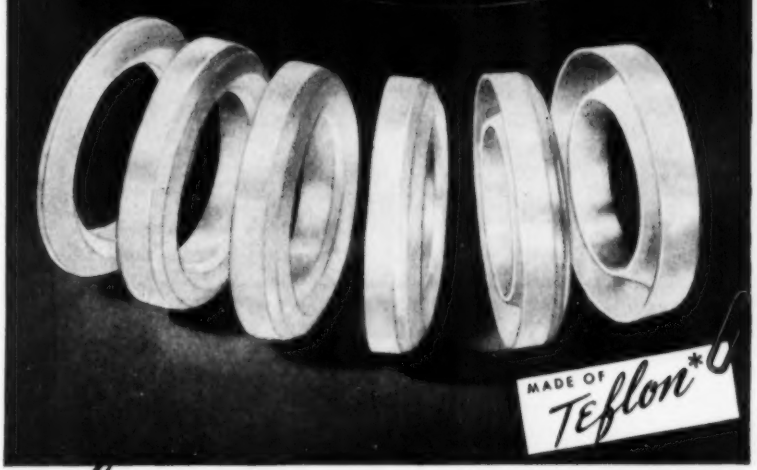
SOLVE YOUR SPECIAL PACKING PROBLEMS..

WITH JOHN CRANE

CHEMLON®

"C-V"

RINGS



for **CORROSION-FREE PACKING SERVICE IN PUMPS AND VALVES....**

You can effectively handle any corrosive liquid or gas by repacking your valves and pumps with "John Crane" Chemlon "C-V" Rings. Molded from the remarkable material, Teflon, "John Crane" Chemlon "C-V" Rings are impervious to almost every known chemical substance. They withstand extreme temperatures from −94° to +482°F—have extremely low friction coefficient. "Breakout" friction is only slightly higher than that of running friction. Special cross sectional design affords positive sealing at practically finger-tight gland pressure.

To bring you all the important advantages of Teflon for your particular sealing problem or application, "John Crane" has developed a complete line of Chemlon "C-V" Rings and male and female adapters. If you have special requirements, additional sizes can be molded to fit your stuffing box dimensions.

"John Crane's" illustrated booklet "The Best in Teflon" contains extensive information on a wide variety of Chemlon Products. Send for your free copy. Crane Packing Co., 1820 Cuyler Ave., Chicago 13, Ill.

*DuPont's trademark for tetrafluoroethylene resin

JOHN CRANE CRANE PACKING COMPANY

NICHOLSON W. O. TRAPS

Cannot Leak Live Steam

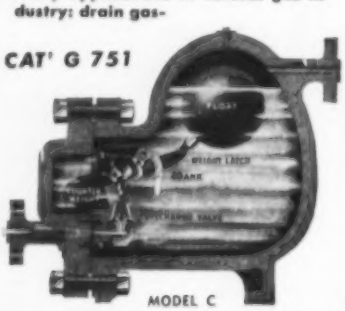
Even though re-evaporation completely dries up its body, a Nicholson weight-operated trap will not leak live steam. Widely used for steam purifiers, super-heated steam lines, headers, separators, heaters, etc.

DRAIN WATER, GASOLINE, OIL

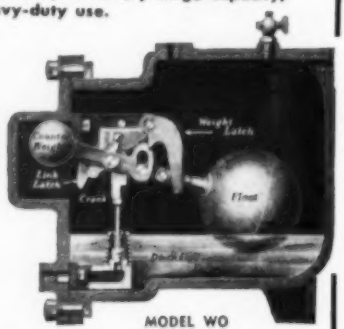
Nicholson W. O. traps also have many applications in natural gas industry: drain gasoline from scrubber head of booster and gas lift compressors; gasoline, oil or moisture from gas well separators, accumulators, after-absorbers, etc.; packaged natural gasoline plants; gas lines.

4 TYPES—press. to 200, 500, 650, 1500 lbs.; for every large capacity, heavy-duty use.

CAT' G 751



MODEL C



MODEL WO

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TRAPS · VALVES · FLOATS

W. S. ROCKWELL Butterfly Valves

for Any Operating Condition to 300 p.s.i. and 2000° F.

Minimum Pressure Drop • Automatic or Manual Control • of any metal or rubber-lined in sizes to 120"

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ROCKWELL SINCE 1888 BUILT

BUTTERFLY VALVES • SLIDE VALVES • AUTOMATIC VALVES

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Sales Representatives in Principal Cities

space on the second floor for the scientific and administrative staffs. The balance of the building will be devoted to radiochemistry laboratories and facilities for nuclear instrument production and research.

Newquist Succeeds Owens as Head Of Roots-Connersville Blower

Dresser Industries, Inc., has announced the appointment of Ralph R. Newquist as president and general manager of Roots-Connersville Blower Division. He succeeds R. H. Owens, who becomes chairman until his retirement later this year.

Newquist

Before joining Roots-Connersville in 1946 as vice president in charge of sales, Newquist was manager of the Washington, D. C., office of Allis-Chalmers Manufacturing Company. Since 1951 he has been executive vice president of Roots-Connersville.

Foy Elected Vice President of Republic; Hamaker Appointed

Election of Norman W. Foy as vice president in charge of sales and appointment of L. S. Hamaker as general manager of sales have been announced by Republic Steel Corporation.

Foy, who was appointed Chicago district sales manager in 1930, when Republic was formed, succeeds J. M. Schlendorf, who will retire from the vice presidency but will continue with Republic in a consulting capacity on sales problems. Foy was promoted to general manager of sales in 1937.

Hamaker became associated with Republic in 1930, when he was advertising manager of steel companies which became a part of Republic. He had received several appointments, the most recent in 1942 when he was appointed general manager of sales for the entire Republic organization.

Combustion Control Names Blaine And Erickson Office Managers

Appointment of Kenneth R. Blaine as Atlanta, Ga., area office manager and Adolph J. Erickson as the Dallas, Texas, area office manager has been announced by Combustion Control Corporation of Boston.

Blaine was formerly with Dodge Engineering Company and Gibson Engineering Company of Washington, D. C. He first joined Combustion Control in 1952 and was assigned as sales engineer to the Washington office.

Erickson was formerly manager of the San Francisco area office, where he supervised sales and also the education of service personnel in the service and installation of Fireye controls.

Daniel Moves Henry to Odessa, Announces Three Other Changes

William R. Henry has been named district manager of West Texas at Daniel Orifice Fitting Company. He will make his headquarters at the company's sales offices and warehouse at Odessa, Texas. He spent several years in the

engineering department at the company's main offices and plant in Los Angeles before transferring to sales.

Freudenthal

Wilson

Henry

Watson

In other changes at Daniel:

W. C. (Bill) Watson, formerly associated with W-K-M Company and the Industrial Valve division of Cameron Iron Works, joined the company's sales force at Odessa.

Merton Freudenthal, in Daniel's engineering department in Houston for three years, has been placed in charge of the company's new Dallas sales office, which was transferred from Ft. Worth.

J. R. Wilson, for the past five years technical assistant in the Pipe Line division of Southern Counties Gas Company of California, has been added to the company's sales staff at Los Angeles.

Carpluk Follows Jamison on Staff Of General Electric Department

Alfred E. Carpluk has joined the sales engineering staff of the Trumbull Electric department of General Electric Company. He will be located in Trumbull's Boston office. He will handle job estimating and layout and will act as engineering and sales liaison with the Trumbull main offices in Plainville.

Carpluk

Carpluk, who replaces J. J. Jamison, recently called to active duty with the Navy, joined G-E in 1949. Before his recent assignment he was a sales engineer with the Small and Medium Motor department of G-E at Lynn, Mass.

25-Year Service Behind Retiring Diamond Alkali Vice President

Fred W. Fraley, vice president—sales of Diamond Alkali Company, has retired. He retired recently as a director of the company.

Fraley's 25-year career with Diamond

WHY INSULATE YOUR CONDENSER TUBES?

You may be doing just that if your plans don't include CHLORINATION EQUIPMENT for slime control by WALLACE & TIERNAN.

Chlorination equipment because it controls slime that *grows* on the walls of condenser tubes not protected against it. Enough of the growth eventually seriously reduces heat transfer efficiency — actually *insulates* your steam from the cooling water. Back pressures go up, production drops, operating and maintenance costs rise, and eventual shut-down becomes necessary for regular clean-out periods.

Wallace & Tiernan equipment because it is versatile, sturdy and dependable — proven by thousands of successful installations, vouched for by satisfied users everywhere—and because there's a Wallace & Tiernan chlorinator for every job. Write today for information on how Wallace & Tiernan chlorination may help you solve *your* slime problem.

NO WATER IS SLIME-FREE

regardless of the source. Chlorination helps reduce slime in process or cooling water.

CD-37

WALLACE & TIERNAN COMPANY, INC.

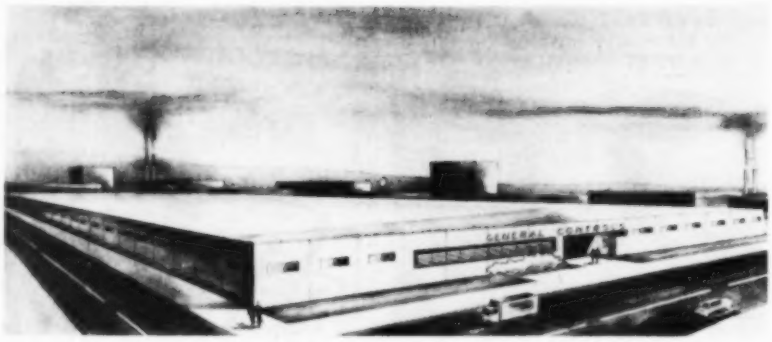
CHLORINE AND CHEMICAL CONTROL EQUIPMENT

NEWARK 1, NEW JERSEY • REPRESENTED IN PRINCIPAL CITIES

began in 1928 as manager of Diamond's Southwest sales office in Houston. He became vice president—sales in 1948 and was named a director in 1947. He has also been a director and former vice president of The Chlorine Institute.

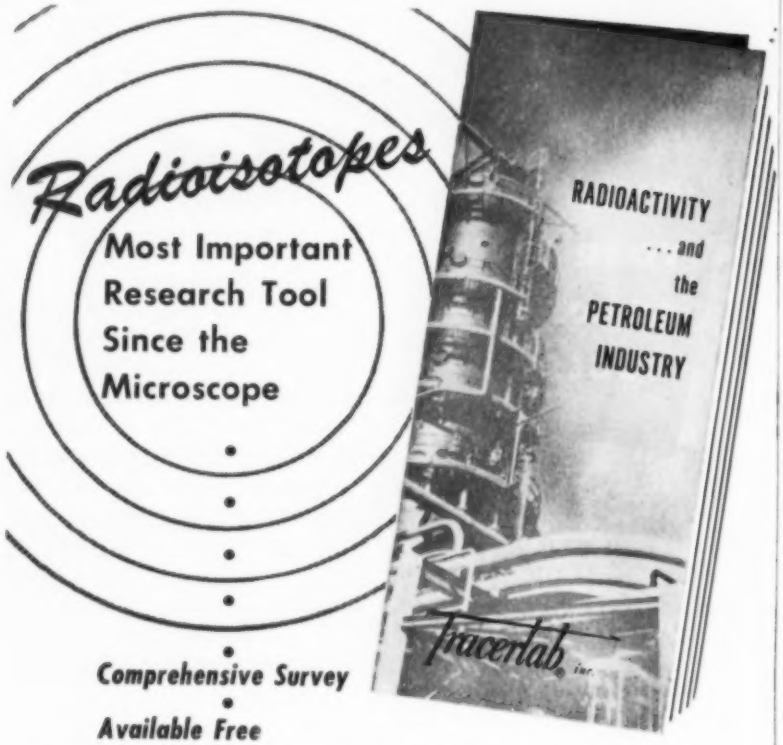
Elliott Promotes Hiller to Washington District Manager

M. L. Hiller, who has been a field engineer in the Washington, D. C., district office of Elliott Company, has been appointed district manager, replacing S. K. Hostetter, Jr. Hostetter has been named sales manager of Elliott's Ampere, N. J., plant. Hiller started with Elliott in the turbine engineering department.



General Controls to Build Plant at Burbank, California—

Marking its third expansion in the past year, General Controls Company will construct the plant shown in the above sketch at Burbank, Calif. The new 120,000-square-foot manufacturing plant is intended to give the company additional production capacity for appliance controls and to free areas in its Glendale, Calif., plant for increased production of other automatic controls which are widely used for domestic and commercial applications. The new plant, being designed and constructed by The Austin Company, is scheduled for completion late this summer.



Tracerlab recently compiled and published a 16-page brochure which surveys most of the known applications of radioactivity in the petroleum industry. Presented in clear, down-to-earth, non-technical language are the facts about isotope use in your industry that you should know. Also included is a valuable three-page bibliography.

This comprehensive booklet was prepared to provide a stimulus to the present users of isotopes to develop new applications, and to acquaint non-users with what has been happening in this highly important new field. Radioisotopes and their unique properties, acknowledged to be the most important new research tool since the discovery of the microscope, should be known to all research and operating people.

Secondly, "Radioactivity and the Petroleum Industry" is intended to acquaint you with Tracerlab. We pioneered in the field of commercial radioactivity and are now the largest firm in the field. We produce the most complete line of nuclear instruments; sell the largest number of "tagged" compounds; provide the most comprehensive consulting service.

Write on your business letterhead — we'll be glad to send a copy of RADIOACTIVITY and the PETROLEUM INDUSTRY.

Tracerlab, Inc.
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LOS ANGELES • PARIS • CHICAGO • CLEVELAND

Laurence Johnston Appointed Vice President of Brown Fintube

Brown Fintube Company, Elyria, Ohio, has announced the appointment of Laurence C. Johnston as vice president. He will continue to manage sales of heat exchangers and all other Brown Fintube heat transfer equipment in the Eastern territory.

Johnston

Johnston joined Brown Fintube in 1949 as Eastern district sales manager. He had previously served with Process Engineering, Inc., and Patterson-Kelly Company. He will continue to make his headquarters at the company's New York offices.

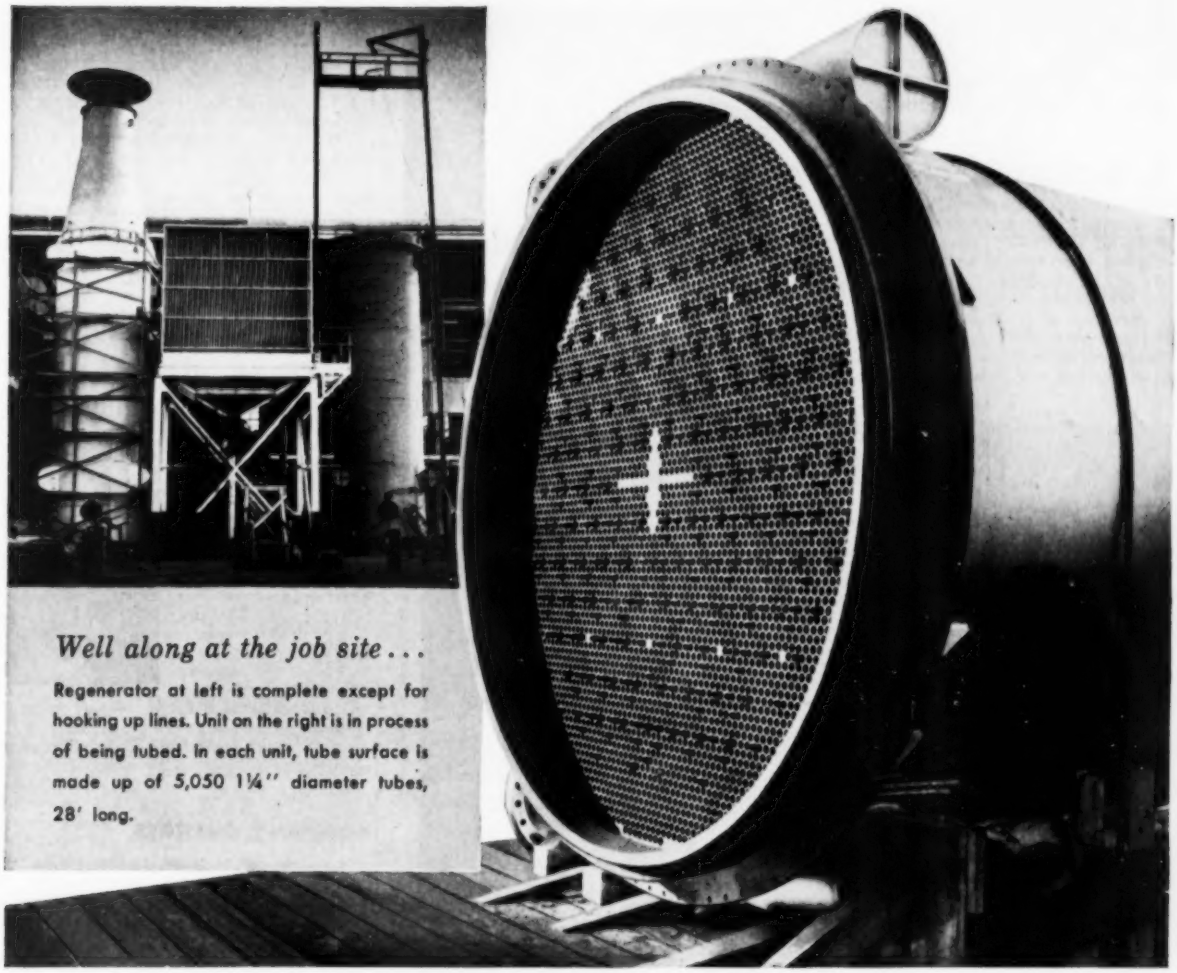
Glass-Lined Smoke Stack Built By A. O. Smith at Milwaukee

The A. O. Smith Corporation has created and erected the first glass-lined smoke stack in industrial history, the company has announced. The three-ton section, 44 feet in length and 6 feet in diameter, was hoisted aloft to form the top section of an 85 foot powerhouse stack at the firm's Milwaukee plant.

Employing techniques developed by its own ceramics laboratory, A. O. Smith coated the stack section inside and out with two glass linings, each approximately 5/1000 inch thick.

Killfoile Named District Manager Of OTM Corporation in New York

OTM Corporation, Houston, has appointed Daniel J. Killfoile Eastern division manager with offices in New York to serve the oil industry along the Eastern Seaboard. Killfoile has 17 years experience in oil and chemical construction materials, both in sales and in the



Well along at the job site . . .

Regenerator at left is complete except for hooking up lines. Unit on the right is in process of being tubed. In each unit, tube surface is made up of 5,050 1¼" diameter tubes, 28' long.

Something New on the Power Horizon

This huge regenerator is heading for service in a natural gas pipeline station in Texas.

This unit and nine more like it were designed and fabricated by Lummus for General Electric Company to serve ten 5,000 hp gas turbines. In this system, the regenerators increase the turbine efficiency cycle by interchange of heat from the exhaust gases to the turbine compressor air.

Each regenerator consists of 46,300 sq. ft. of tube surface, heating 338,000 lb./hr. of air to 831° F, using exhaust gas from the turbine entering at 920° F. A stainless steel expansion joint was installed in the top portion of the shell to compensate for thermal expansion between the shell and tubes.

Due to the size of these units, it was necessary to insert 95% of the tubes in the field after the units were erected in their vertical position. The fact that this was carried out without a hitch provides another example of where Lummus accuracy paid off.

It is the new, unusual, tough jobs like these that confirm Lummus' reputation as engineering pacesetters. We urge *you* to rely on Lummus when your next heat transfer job comes up!

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Steam Surface Condensers • Evaporators • Extraction Bleeder Heaters • Steam Jet Air Ejectors • Steam Jet Refrigeration • Barometric Condensers • Heat Exchangers for Process and Industrial Use • Process Condensers • Pipe Line Coolers.

field. He was formerly associated with Chemical Construction Corporation.

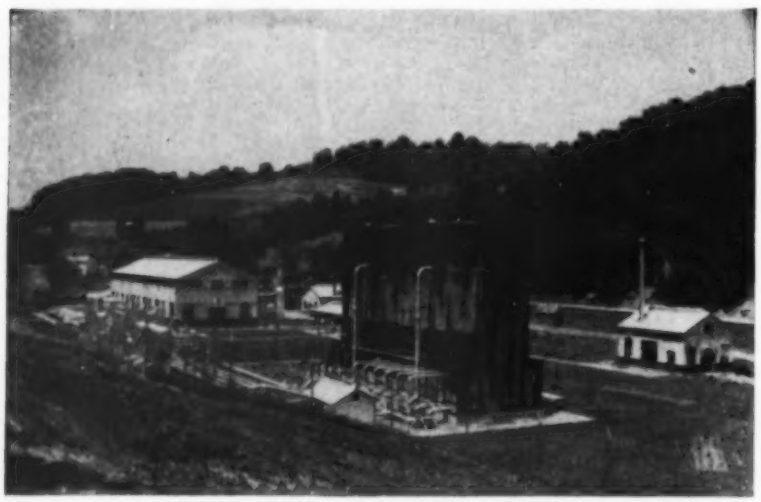
Markley and Deal Top Promotions Made by Timken Roller Bearing

The following promotions were announced recently by The Timken Roller Bearing Company:

H. E. Markley, assistant secretary, has been elected secretary; G. L. Deal, assistant treasurer, was elected treasurer; B. R. Powell, chief cost accountant, has been named assistant secretary; and R. A. Gulling, systems supervisor, has been elected assistant treasurer. The promotions were brought about by the retirement of J. A. Riley, secretary-treasurer, who joined Timken in 1925 as comptroller in charge of all accounting.

Deal Markley

Markley joined the company in 1938 as an accountant trainee. He was named secretary in 1947.



Preston Station, near Waynesburg, Pa., one of the compressor plants of the New York State Natural Gas Corporation.

THE PICTURESQUE AND EFFICIENT PRESTON COMPRESSOR STATION OF

New York State Natural Gas *Uses* FLORITE

A showplace for sightly layout and natural beauty of surroundings, the Preston compressor plant of New York State Natural Gas Corporation is also a model of advanced methods and efficiency. It is one of several stations operating at very high pressures in the great hookup that delivers Texas gas to cities in the Rochester-Syracuse region of western New York, and has an uncommon record of freedom from accidents or delays. Gas is dehydrated by two contact towers employed alternately in a 24-hour cycle, one being regenerated while the other is in use. The drying agent is Florite, and the volume of gas processed daily is 160 million cubic feet.

Florite will selectively adsorb 4 to 20% its weight of water—is regenerated by heating to 350° F. Write for literature.

FLORIDIN COMPANY ADSORBENTS DESICCANTS DILUENTS

Department E. 220 LIBERTY STREET WARREN, PA.

Chiksan Field Engineer to Work With Esso Standard in Guatemala

Chiksan Company has sent Robert T. Jones, field engineer, from the Brea, Calif., plant to San Jose, Guatemala, to work with Esso Standard Oil Company on its undersea unloading lines which discharge butane, propane, and other petroleum products from tankers to a bulk station on shore.

Jones will render assistance and advice on the use of Chiksan ball-bearing swivel joints on these submerged lines.

Cooling Tower Institute Elects Leon T. Mart 1953 President

Leon T. Mart, president of The Marley Company, Kansas City, Mo., was recently elected president of the Cooling Tower Institute. Other officers elected for 1953 terms were: Neal B. LauBach, Hudson Engineering Corporation, Houston, vice president; Paul R. Hoffman, Lilie-Hoffmann Cooling Towers, St. Louis, secretary; Clayton E. Pickup, The Fluor Corporation, Los Angeles, trasurer. Executive offices of the Institute at Palo Alto, Calif., continue under the direction of Raymond C. Kelly, executive manager.

Mart

COMPANY CHANGES

John T. Walmsley, who has been in Hooker Electrochemical Company's Niagara Falls sales office since June, 1952, has been promoted to the company's Chicago and Midwest area as a salesman . . . **Wheelco Instruments division, Barber-Colman Company,** has added the following factory trained engineers to its sales and service organization: **Robert Unger,** service engineer, Chicago; **Harold L. Dirkers,** sales engineer, and **Leonard V. Bloom,** service engineer, Detroit; **William E. King,** service engineer, New York; **Lawrence S. Holbrook,** service engineer, and **Robert Hemman,** sales engineer, Boston; **Scott R. Babcock,** service engineer, and **Clyde Person,** service engineer, Rockford, Ill. . . . **Shand & Jurs** has moved from its former New York headquarters at 295 Madison Street to enlarged quarters at 342 Madison Street . . . **Cleaver-Brooks Company,** Milwaukee, has appointed **Hi-Way Equipment Company, Inc.,** Houston, as a distributor for the Road Machinery division. Products of this division include stationary and mobile equipment designed for use in asphalt plants, heating and unloading of bituminous materials, pile driving and extracting, curing of concrete block and all concrete cast products . . . **H. H. Gorrie,** assistant chief engineer of **Bailey Meter Company,** has been appointed chief engineer of the company. He has been with Bailey since 1927.

Frank Row, formerly LPG sales coordinator for **A. O. Smith Corporation's** Houston Works, and **J. P. Parker,** formerly manager of the company's Rural Sales division, have been selected regional managers within the corporation's

Liquefied Gas Products division. Row has been named Southern Regional manager with headquarters at Houston, and Parker has been appointed manager of the Northern Region at Chicago . . . **S. R. Zimmerman, Jr.,** has been elected a director of **Raybestos-Manhattan, Inc.** He was appointed assistant general manager of the United States Asbestos division in January of this year . . . **Rust-Oleum Corporation** has added two new industrial distributors to its nation-wide distributor sales organization. They are: **Seaboard Mill Supply Company,** New Brunswick, N. J., and **E. Blankenship and Company, Inc.,** Marion, Ill. . . . **E. H. McGrew,** formerly of Universal Oil Products Company, has been named technical director of the Catalyst division of **National Aluminate Corporation.** He will be located at the Nalcat Chicago plant as assistant to Dr. D. G. Braithwaite, assistant vice president of Nalco.

Cooper-Bessemer Opens Warehouse At Edmonton Under Van Fossen

A new branch office and parts warehouse has been opened by Cooper-Bessemer of Canada Limited in Edmonton, Canada, under the direction of Edward D. Van Fossen. This latest addition to Cooper - Bessemer's world-wide sales and service facilities is planned to provide prompt factory service for Cooper-Bessemer products.

Van Fossen

Van Fossen, formerly at the company's district office in Seattle, has extensive experience in many phases of power generation and compressor operation serving the Canadian sector.

Al Rothenbuhler, serviceman at Cooper-Bessemer's warehouse at Great Falls, Mont., since 1949, heads the service staff at the Edmonton warehouse. Assisting him is William Munro, warehouseman who was formerly with the British Columbia Power Commission.

ALCOA Liquidates Subsidiary And Adds to Advertising Staff

Liquidation of a subsidiary and an addition to its general advertising staff have been announced by Aluminum Company of America.

ALCOA Mining Company, the wholly owned subsidiary, has been liquidated to simplify the parent company's corporate structure. The subsidiary's operations will be transferred to the newly created Mining division of ALCOA. There will be no change in functions and responsibilities of the mining company's personnel.

John C. Spencer, a member of ALCOA's sales department since 1949, has joined the company's general advertising staff in Pittsburgh. Spencer has specialized in aluminum architectural product sales at ALCOA's Atlanta, Ga., office.

Foxboro Establishes Affiliate

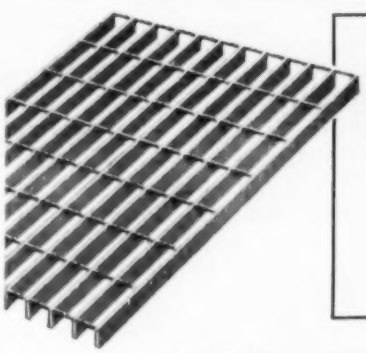
Organization of a Mexican affiliate, Graficas e Instrumentos, S. A., has been announced by The Foxboro Company of Foxboro, Mass. Located in Mexico

SKILL . . .

the basic element for which there is no substitute in the design and construction of every MURRAY steam turbine. Let MURRAY'S special skill and experience be your guide the next time you specify a steam turbine drive.

See your Murray Representative or write for information

MURRAY IRON WORKS CO.
Burlington, Iowa



Make those **OPEN SPACES**
SAFE and USABLE
with this unique, one-piece
OPEN STEEL FLOORING

SILENT! STRONG! SECURE!

Uncovered pits, light wells, cellar stairways, etc. quickly become safe and usable areas when floored with Blaw-Knox Electroforged Steel Grating. Made in one piece . . . no nuts or bolts to rattle or lose. Provides safe footing even when wet or greasy and lasts indefinitely. Admits maximum light and air. Furnished in any shape, cut to fit. Just send dimensional sketch of area to be covered and we will forward price by return mail.

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Grating Department
BLAW-KNOX EQUIPMENT DIVISION
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ELECTROFORGED® STEEL
BLAW-KNOX GRATING

City, the new firm has been incorporated for the future manufacture and assembly of instruments and instrument supplies.

The new concern has obtained factory facilities adjacent to Schultz y Cia., Foxboro's sales representative in Mexico. It is the third to join the list of Foxboro's international affiliates.

Elliott Announces Office Change, Appoints Carlson and Mateffy

The following changes have been announced by Elliott Company:

Its district office in Tulsa has been moved from 616 McBirney Building to 910 Petroleum Building.

W. S. Carlson, who joined the company and was assigned to Minneapolis in June, 1951, has been appointed manager of the Minneapolis district office.

H. D. Mateffy has been appointed branch manager at Duluth, Minn.

Harry A. Pastre, retired vice president of the company, died recently at the age of 80. He was associated with W. S. Elliott even before the latter founded the company in 1901. He was Elliott's first salesman.

Kellogg Company Issues Number One Of New Bi-Monthly Employe Magazine

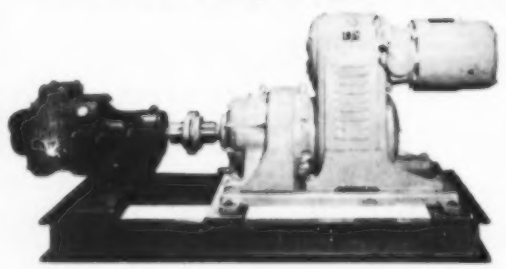
The first issue of a bi-monthly magazine for employes has been published by The M. W. Kellogg Company. Entitled "Kellogg World," the two-color publication will be mailed to the homes of employes. It features articles about the company's operations and the activities of employes. Editor is Virginia Campbell, for four years assistant editor for a magazine published by American Viscose Corporation.

Macco Completes Remodeling and Enlargement—

Macco Corporation has completed remodeling and enlarging its main offices at 14409 Paramount Boulevard, Paramount, Calif., executive headquarters for the company's Construction, Refinery, Rig Building, Pipeline, Drilling Fluid and Lumber divisions.

The building was extended 35 feet to provide larger engineering quarters. The entire 260 foot front of the one-story structure was remodeled. The foyer was enlarged and redecorated and ten new offices were added to increase the total office floor space to more than 17,000 square feet, according to company officials.

An Interesting VIKING Unit



Viking Pumps are leaders in service to the Oil Industry . . . tops in performance and dependability.

Shown here is a versatile unit of the heavy-duty style designed to handle thin or viscous liquids. Capacity ranges from 10 GPM to 1050 GPM with pressure to 200 lbs. This unit shows totally enclosed vari-drive with a wide speed range.

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We don't have the largest steel fabricating plant in the world but some of the largest Petro-Chemical installations have used Steel by Dollinger. Why? For many reasons . . . Prompt Service, Experience, Dependable Delivery and a Competitive Price.

It takes more than machines to produce steel for the Petro-Chemical Industry. It takes years of experience. The John Dollinger, Jr., Corporation has that experience. That's why more and more firms are calling upon Dollinger to help them meet their fabricated steel requirements.

FOR OVER 50 YEARS, LEADERS IN THE PETRO-CHEMICAL INDUSTRY HAVE LOOKED TO JOHN DOLLINGER, JR., INC. FOR QUALITY STEEL FABRICATION AND DEPENDABLE DELIVERY.

DOLLINGER AROUND THE WORLD.

For inquiries regarding fabricated structural steel and plate steel, write to John Dollinger, Jr., Inc., Beaumont, Texas.

Blackmer Names Thornburg Head of South Central Division Sales

Ralph Thornburg has been appointed division sales manager of the South Central division for Blackmer Pump Company of Grand Rapids, Mich.

Thornburg

Thornburg was formerly sales manager of the Pump division, Yale and Towne Manufacturing Company. Most recently he was Eastern district manager of Marlow Pumps. A graduate of the University of Oklahoma, he will maintain residence in Dallas.

Fluor Names New Vice President To Head Mid-Continent Sales Area

Appointment of J. W. Elizardi, Jr., as vice president in charge of Mid-Continent area sales for The Fluor Corporation, Ltd., has been announced. He will headquarter in Houston.

Elizardi

Elizardi was formerly Gulf Coast manager for The Marley Company and, prior to that, served for many years as vice president in charge of petroleum sales for The Griscom-Russell Company. He is a graduate of Tulane University.

Arizona Chemical Names Spruance Technical Sales Representative

H. Douglas Spruance has been named Arizona Chemical Company's technical sales representative for the Mid-West. Spruance, whose headquarters will be at American Cyanamid Company's office and warehouse in Chicago, will service customers in Michigan, Illinois, Minnesota, Wisconsin, Iowa and Missouri.

Spruance has spent the last seven years at the Linden, N. J., research laboratory doing application and sales service work on Arizona's tall oil products as applied to alkyd resins, oleoresinous varnishes and paints, core oils, esters and soaps.

Ampco Metals Appoints Koerper Works Manager at Milwaukee

Appointment of Erhardt C. Koerper as works manager has been announced by Ampco Metal, Inc., Milwaukee. In his new post, the works manager will direct the company's entire production activity.

For the past nine years, Koerper has been assistant executive engineer at A. O. Smith Corporation, engaged in special products engineering and the coordination between laboratories and production. Prior to his association with A. O. Smith he was a consultant on important A.A.F. engineering and production programs.

Kold-Hold Changes Name

Kold-Hold Manufacturing Company, Lansing, Mich., has changed its corporate name to Tranter Manufacturing,

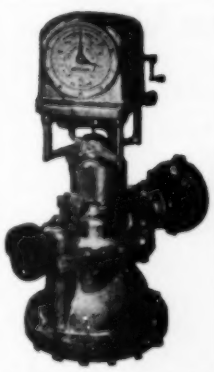
NAGLE designs and builds centrifugal pumps for abusive applications - - - abrasive or corrosive.

The complete line of Nagle vertical and horizontal shaft pumps is engineered to solve tough pumping problems—which Nagle Pumps have done in **every** industry confronted with such problems. Send for catalog.

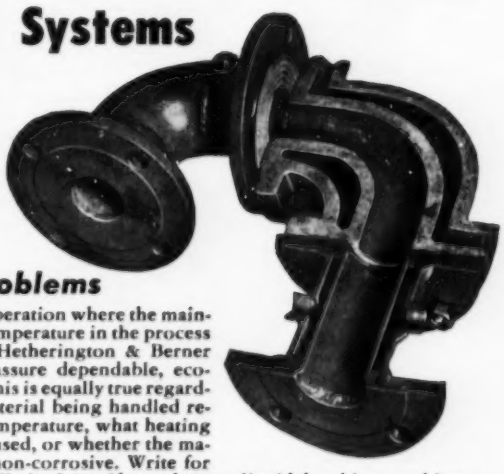
NAGLE PUMPS

NAGLE PUMPS, INC.
1251 Center Ave., Chicago Heights, Ill.

PUMPS FOR ABRASIVE AND CORROSIVE APPLICATIONS



COMPLETE Jacketed Pipe and Fluidometer Systems



for all liquid-handling problems

● In any processing operation where the maintenance of a uniform temperature in the process pipes is necessary, a Hetherington & Berner jacketed system will assure dependable, economical production. This is equally true regardless of whether the material being handled requires a hot or cold temperature, what heating or cooling medium is used, or whether the material is corrosive or non-corrosive. Write for Bulletin J-50. If you have a liquid batching problem, involving either light or heavy liquids, jacketed or unjacketed construction, investigate the *Fluidometer System.* This system gives accurate, dependable and *completely automatic* batching and is adaptable to practically any liquid measuring problem, whether it involves gallons, barrels or tank cars. Write for Bulletin Fl-49.

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For your local H & B Distributor see Refinery Catalog Page 587

Send for descriptive bulletin CT-102

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CALIBRATING TANKS

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TERMINALS
PIPE LINES
TANK TRUCKS
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Faithful Performance on Important Jobs

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Capacities to 1,200 G.P.M.

Heads to 460 Ft.

PUMPS "by Aurora"

TYPE-AD Aurora Horizontally Split Case, Back-to-Back Impellers, Two Stage Centrifugal Pump. Particularly suited to clear water and low viscosity liquids not containing solids. Write for BULLETIN 106

For Every Purpose

APCO TURBINE-TYPE PUMPS are unbeatable on low capacity, high head duties.

AURORA CENTRIFUGAL PUMPS are available in many types and sizes —all noted for their streamline coordination between impellers and shells.

Capacities to 150 G.P.M. Heads to 500 Ft.

Write for CONDENSED CATALOG "M"

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AURORA Always PUMPS

AURORA PUMP COMPANY

Subsidiary of The New York Air Brake Company
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Inc. The change was voted by stockholders.

The Kold-Hold name will be retained to indentify a division of Tranter Manufacturing.

Bristol Transfers Sam Gewin to St. Louis as District Manager

Sam E. Gewin has been appointed district manager of the St. Louis office of The Bristol Company, Waterbury, Conn. His new headquarters will be in the company's St. Louis office.

Gewin

After graduating from the University of Alabama with a degree in chemistry, metallurgy and ceramics, Gewin was associated with U. S. Industrial Chemical Company for three years prior to joining Bristol. He joined the Bristol organization in 1937 as a sales engineer. For the last five years he has been resident sales engineer in the Buffalo area.

Williams to Head Industry Group Formed in Owens-Corning Division

Organization of a new industry group to sell the complete line of Kaylo and Fiberglas insulations has been announced by the General Products division of Owens-Corning Fiberglas Corporation.

Williams

Heading the new group will be Hugh T. Williams, who has had more than 13 years experience in the industrial insulation sales and engineering fields. He will report to D. M. Barthold, sales manager of the Industrial Construction Materials division.

Williams was formerly with the Kaylo Sales division of Owens-Illinois Glass Company, handling special assignments and directing a sales-educational program in industrial insulation.

Clark Equipment Names Christy New Dealer for Omaha Territory

The Christy Equipment Company has been appointed a new dealer for Clark Equipment Company's fork lift trucks, powered hand trucks and towing tractors.

Heading the new dealership are Gordon K. Christy and Charles O. Christy. Gordon Christy has been a salesman for Clark for eight years. The dealership, located in Omaha, replaces the Clark dealership in Sioux Falls, S. Dak.

New Odessa Plant Established By Graver Tank & Manufacturing

Graver Tank & Manufacturing Company, Inc., has established a new plant at Odessa, Texas, bringing to six the total number of plants operated by the company. Situated on a seven-acre site, the new installation will serve as an important adjunct to Graver's lease tank fabricating facilities at the company's

Catawissa PERFECT SEAL Unions

HOT FORGED from solid, rectangular steel bars, designed and produced for dependable, long-life service under the severest piping conditions!

A TYPE FOR EVERY USE!
FOR ALL PRESSURES!
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Standard & Double Extra Heavy UNIONS

Available with screwed or socket weld ends. 3000-lb. sizes ⅛" to 3"; 6000-lb. sizes ⅛" to 2".

ORIFICE UNIONS

With screwed or socket weld ends. 3000-lb. and 6000-lb. service.

MALE & FEMALE UNIONS

With steel-to-steel, bronze-to-steel, stainless steel-to-steel or orifice seats. 3000-lb. service only.

Standard & Double Extra Heavy LUG NUT UNIONS

Hammer-type for quick opening and quick closing.

write for your free copy of
CATALOG 11
for complete information

CATAWISSA VALVE AND FITTINGS COMPANY
60 Mill St. · CATAWISSA, PA.

plant at Sand Springs, Okla. Warehouse space at Odessa will permit storing of wellhead equipment manufactured at Sand Springs and shopbuilt lease tanks of 500-barrel and 1000-barrel capacities fabricated at Odessa.

MacNamara Becomes Manager of Beckman Instrument Field Sales

Beckman, Instruments, Inc., South Pasadena, Calif., has named John D. MacNamara, veteran of over 12 years industrial and instrument sales experience in the eastern states, field sales manager.

MacNamara

His appointment follows a recent enlargement of the company's national field staff. Initially he will oversee the training of 20 new field engineers and will co-ordinate their activities to provide maximum service for research and process industries over the country.

In 1946 MacNamara joined the Industrial division of Minneapolis-Honeywell Regulator Company, where he last served as textile industry sales manager.

Ewalt Gets New Hooker Position

Wolford M. Ewalt has been made special products supervisor in the Niagara sales office of Hooker Electrochemical Company. For the past two

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Now in preparation. Gulf Publishing Company's new free book catalog will be ready soon. It will list the numerous books on all phases of the oil industry for sale through Gulf Publishing Company.

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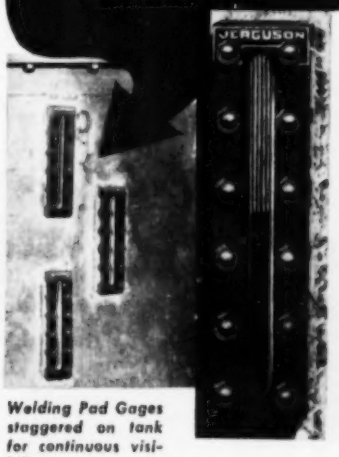
JERGUSON
WELDING PAD GAGES
are integral part of this tank



Welding Pad Gages staggered on tank for continuous visibility.

HERE is a special line of gages that weld right to the liquid containing structure, thus becoming an integral part of it. It solves problems where it is impractical for you to use a conventional type gage because of solids in suspension in a liquid, etc.

These Special Gages follow Jerguson Standard Gages in general design and materials, except for the method of attaching. The chamber of the gage consists of a bar steel pad which is welded to the vessel.

Welding Pad Gages are made in both Reflex and Transparent types . . . in all sizes of Jerguson Standard Gages. Pressure ratings are available to your specific requirements. Welding pad may be of any metal desired to withstand corrosive or other conditions.

Write for Data Unit on Welding Pad Gages for complete details. Whatever your gage problems, let Jerguson engineers assist you.

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W. H. CURTIN & CO.
DOMESTIC EXPORT
LABORATORY APPARATUS & CHEMICALS
HOUSTON · NEW ORLEANS
TULSA · BIRMINGHAM · U.S.A.

and one-half years, Ewalt has been in charge of technical correspondence in the technical service division of the sales department. He has been employed by Hooker since 1941, starting as a chemical operator.

Chicago District Sales Manager Appointed by Two BS&B Divisions

Oilfield Sales division and Safety Head, and Venting Equipment Sales division, Black, Sivalls & Bryson, Inc., have announced the appointment of Dick Cwik as Chicago district sales manager for both sales divisions.

Cwik

Cwik has been with BS&B for the past five years as a salesman and as a city sales manager. In his new capacity he will have supervision of sales and service activities of the Oilfield division and the Controls, Safety Head and Venting Equipment division in the Chicago sales district.

Nordberg Manufacturing Names New Distributor in Southwest

Appointment of Southern Engine & Pump Company as distributor for Nordberg 4FS Diesel engines in 117 Texas counties and Southern Louisiana has been announced by Nordberg Manufacturing Company.

Nordberg 4FS Diesel engines will be sold and serviced through Southern Engine & Pump Company branches located at Dallas, Edinburg, Kilgore, and San Antonio, Texas, and in Houma, La.; also through offices at Lafayette and New Orleans, Louisiana.

Sealol and Flexibox Complete Mutual Licensing Agreement

Under a mutual licensing agreement completed between Sealol Corporation, Providence, R. I., and Flexibox, Ltd., of Manchester, England, Sealol is to have the American and Canadian manufacturing rights to the Flexibox seal. Flexibox will have the same privileges with the Sealol seal for western Europe, England and Australia.

Rockwell Manufacturing Shifts Instrument Production to Tulsa

Rockwell Manufacturing Company's Meter and Valve division has announced it is transferring all of Rockwell's gas industry instrument production from Pittsburgh to the firm's Macnick division plant in Tulsa.

When the move is completed, all Rockwell combined record gages, emcorrectors, flow line improvers and flow line indicator meters will be turned out at the Tulsa plant. There will be no physical expansion at Tulsa, but some machinery will be moved there from Pittsburgh and new employes will be added.

Hamer Licenses British Company

Joshua Hindle & Sons, Limited, Leeds, England, has been licensed by Hamer Oil Tool Company of Long Beach, Calif., to manufacture and market

NATIONAL AIROIL
FUEL OIL · GAS
BURNERS
SERVING INDUSTRY FOR 41 YEARS
• Steam Atomizing Oil Burners
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VALVE LUBRICANT

WITH MOLY-DISULPHIDE
High temperature, non-melting silica base valve lubricant with low friction moly-disulphide. Use JET-LUBE VL-5 on valves that are hard to turn. Resistant to hydro-carbons, water, acids, sulphur and alkalies. Batch controlled. Fully guaranteed.
Order through your supply store or send for complete details
JET-LUBE INC.
7362 W. BEVERLY BLVD., LOS ANGELES 36

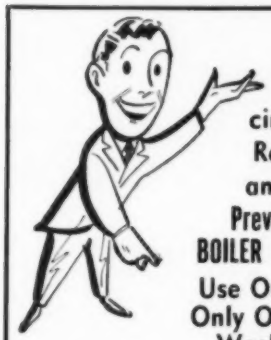
Hamer line blind valves in England and other sterling areas. Under the agreement, Hamer Oil Tool will supply Joshua Hindle & Sons with working drawings of the line blind valves.

Marley Relocates Houston Office

To give necessary space to its expanding Houston plant, The Marley Company has moved its sales office from the plant to a separate office at 1601 Commerce Building in downtown Houston. Roy W. Maze, who joined Marley in 1946 as advertising manager, has been appointed manager.

Inco Publications Head Dies

Edward C. Badeau, in charge of Special Publications section of The International Nickel Company, Inc., and editor of Inco magazine, died recently from a heart attack. He was 58.



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Pure Colloidal Concentrate

One can you can hold in your hand (all active ingredients) safeguards 1-250hp rated Boiler for 1 month.

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Since 1915
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SAND AND CEMENT
"Placed by Air"

38 YEARS OF SERVICE TO AMERICAN GOVERNMENT and INDUSTRY

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Engineering Research

Major petroleum company's centralized Engineering & Construction Department, which renders all phases of engineering service to every department in the company, has an unusual opportunity for a man to manage the Engineering Research Division. We are looking for a graduate engineer with an impressive record of accomplishment in engineering methods, standards, and testing. Must be thoroughly familiar with electrical, mechanical and metallurgical aspects of process equipment and construction materials. For further details, send a brief statement of your training and experience in strict confidence to H. M. Overley.

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Young engineers capable of mechanical estimating for construction of refineries, steam power and similar industrial projects. Must have some field experience.

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Write, give complete details of experience, background, etc., to:

Arthur G. McKee & Co.
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GLASSES & GASKETS

ALL SIZES TO FIT YOUR GAGES & VALVES
ERNST WATER COLUMN & GAGE CO.
Send for Catalog, LIVINGSTON, N. J.

Raybestos-Manhattan Veteran Dies

Sumner Simpson, 79, board chairman of Raybestos-Manhattan, Inc., died recently at Bridgeport, Conn. Influential in the merger in 1929 in which Royal Equipment Company became Raybestos-Manhattan, Inc., he was its only president until a few years ago.

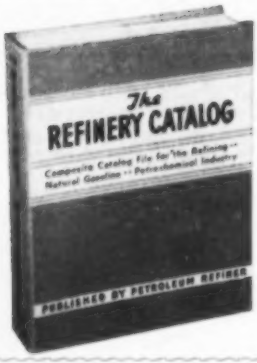
Machine Company Founder Dies

Ernest W. Krause, chairman of the board and founder of Wheeling Machine Products Company, died at his home in Wheeling recently. He was 76 years old.

Sonneborn Founder Dies

Dr. Ferdinand Sonneborn, founder and president of L. Sonneborn Sons, Inc., New York, died recently after a long illness. He was 79.

[Advertisers in the July Issue]



They're in The Refinery Catalog

* The asterisk preceding name of advertiser indicates that detailed data on products and services of the firm will be found in The 1953 Refinery Catalog.

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B&W BULLETIN 6-F

Properties of Carbon, Alloy and Stainless Steel Tubing for High-Temperature and High-Pressure Service

The Story of the Croloys

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- Chemical Composition
- Room-Temperature Properties
- Short-Time Tensile Properties
- Stress-Rupture
- Creep
- Thermal Expansion
- Thermal Conductivity
- Impact Properties
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- Air-Hardening Properties
- Effect of Hydrogen
- Common Causes of Tube Failures
- Upset, Formed and Machined Tube-Ends

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Croloy 1¼	1.25% Cr 0.50% Mo	1100F
Croloy 2	2% Cr 0.50% Mo	1150F
Croloy 2¼	2.25% Cr 1.00% Mo	1175F
Croloy 3-M	3% Cr 0.90% Mo	1175F
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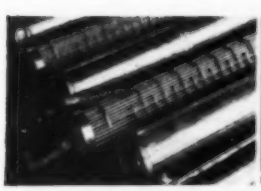

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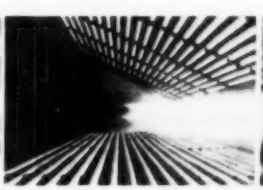

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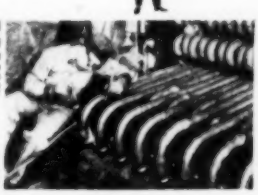

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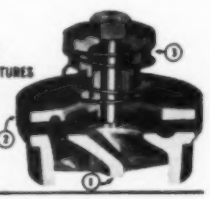

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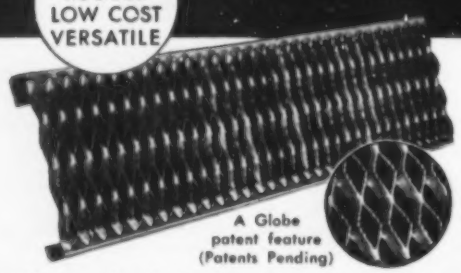

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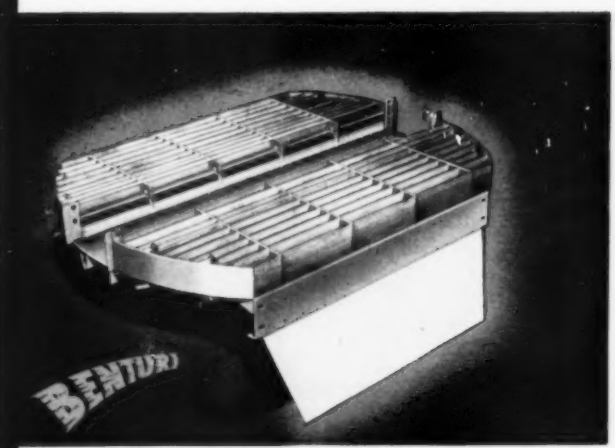

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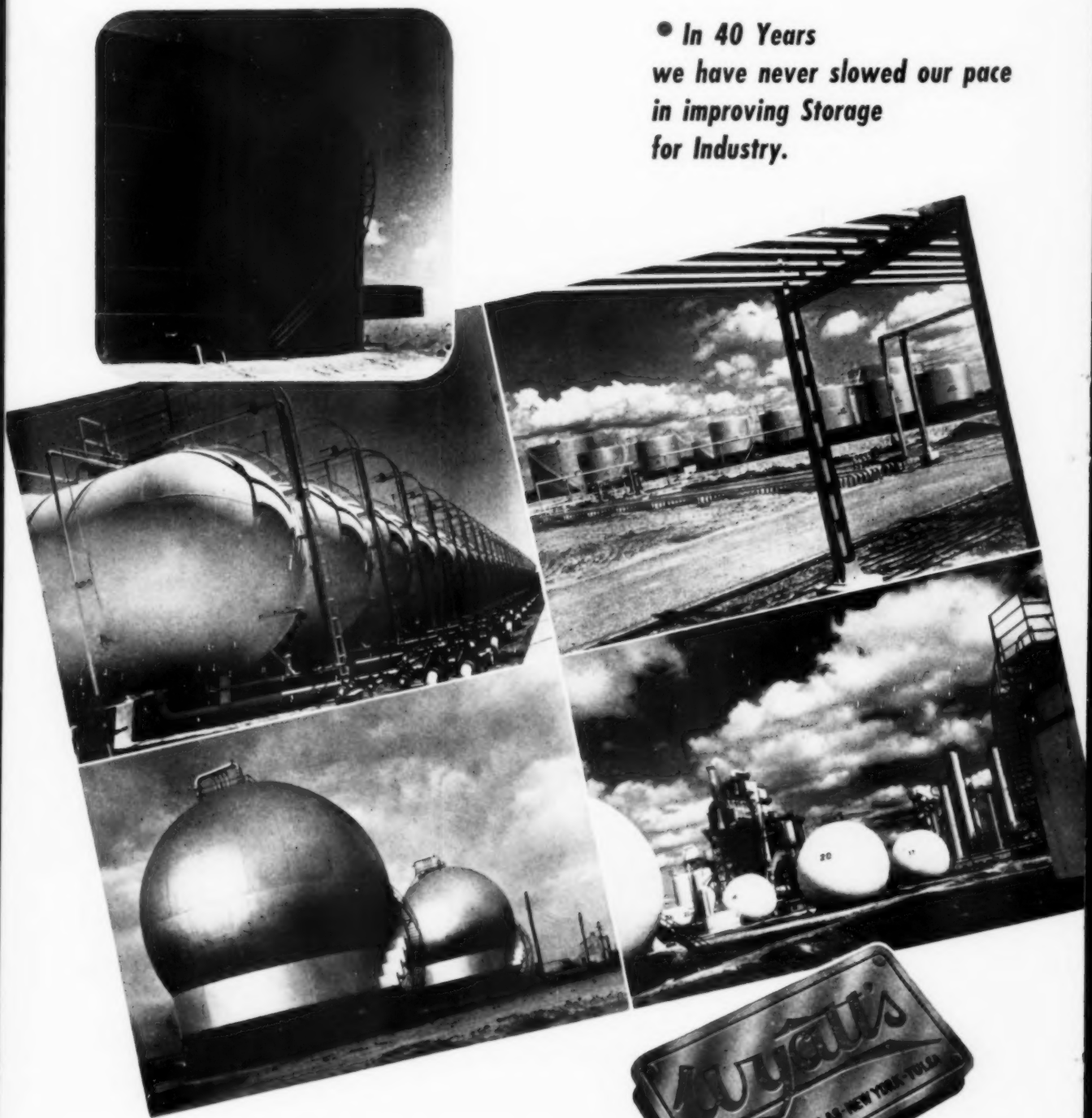

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